POSTPARTUM DEPRESSION/ANXIETY AND MOTHER-INFANT RELATIONSHIPS

THE IMPACT OF MATERNAL POSTPARTUM DEPRESSION AND/OR ANXIETY ON

MOTHER AND INFANT PERFORMANCE ON THE FACE-TO-FACE STILL-FACE TASK

By KWADJO NTOW, H. B.Sc.

A Thesis Submitted to the School of Graduate Studies in Partial Fulfilment of the

Requirements for the Degree Master of Science

McMaster University MASTER OF SCIENCE (2020) Hamilton, Ontario (Global Health)

TITLE: The impact of maternal postpartum depression and/or anxiety on mother-infant performance on the face-to-face still-face task

AUTHOR: Kwadjo Ntow, H.B.Sc. (McMaster University)

SUPERVISOR: Dr. Ryan J Van Lieshout (M.D., Ph.D., FRCP(C))

COMMITTEE MEMBER: Dr. Louis A. Schmidt (Ph.D.)

NUMBER OF PAGES: xiii, 120

Lay Abstract

Maternal postpartum depression (PPD) and postpartum anxiety (PPA) are the most common mental health complications of birth. Apart from unfavourable effects PPD and PPA have on mothers, it may also impact the mother-infant relationship, leading to adverse infant outcomes. Given the relatively high prevalence of maternal PPD, PPA, and comorbid PPD and PPA, this thesis aimed to examine the differences in how mothers suffering from PPD and/or PPA and their infants coordinate their behaviour, in comparison to healthy mothers and their infants using a validated observational task (face-to-face still-face [FFSF] task). Another goal of this thesis was to investigate whether the benefits of maternal treatment for PPD with cognitive behavioural therapy may extend to infants and improve mother, as well as infant behaviour. These investigations may provide new insights on how maternal PPD and/or PPA affects mother-infant interactions, and consequently, infant socio-emotional development.

Abstract

Background: Research suggests that postpartum depression (PPD) and postpartum anxiety (PPA) impact both mothers and their infants, leading to adverse behavioural outcomes across the lifespan. The face-to-face still-face (FFSF) task is a validated observational tool used to measure the quality of mother-infant interactions. This thesis aimed to investigate the differences in responses to the FFSF task between dyads consisting of mothers with PPD and/or PPA and healthy dyads. Another goal was to examine whether PPD treatment could improve mother and infant FFSF outcomes.

Methods: A systematic search was performed in PubMed/MEDLINE, EMBASE, CINAHL, PsycINFO and Web of Science. Meta-analyses were conducted to examine the differences in infant, maternal and dyadic FFSF outcomes in mothers with PPD, PPA or comorbid PPD and PPA in comparison to healthy control dyads. Second, we examined whether group cognitive behavioural therapy (CBT) for PPD could help improve infant and maternal FFSF outcomes. A case-control design study was conducted with three different assessment points (i.e., pre-CBT treatment, immediately after CBT and three months post-CBT).

Results: Meta-analyses suggested that the infants of mothers with PPD display lower levels of positive affect during the play and reunion phases compared to the infants of healthy non-depressed mothers. Also, mothers with PPD may engage less positively with their infants at the reunion phase, and mother-infant dyads affected by PPD show less positive interactive matching during the play phase compared to healthy control dyads. Finally, object/environment engagement was higher in infants of PPA mothers compared to healthy controls at still-face.

Conclusion: The results suggest that mothers with PPD and/or PPD (and their infants) may exhibit different interaction patterns compared to healthy dyads. Also, it appears that the benefits of CBT for maternal PPD may extend to their infants through reductions in maladaptive infant withdrawn behaviours to normal, healthy levels.

Table of Contents

List of Figures

Chapter Three

List of Tables

List of all Abbreviations

BDI: Beck Depression Inventory
BORIS: Behavioural Observation Research Interactive Software
CBT: Cognitive Behavioural Therapy
CIDI: Composite International Diagnostic Interview
DSM: Diagnostic and Statistical Manual of Mental Disorders
EPDS: Edinburg Postnatal Depression Scale
FFSF: Face-to-Face Still-Face
ICD-10: International Classification of Diseases, Tenth Revision
ICEP: Infant Caregiver Engagement Phases
IPT: Interpersonal Therapy
IRSS: Infant Regulatory Scoring System
MDD: Major Depressive Disorder
MINI: Mini International Neuropsychiatric Interview
MOOSE: Meta-Analysis Of Observational Studies in Epidemiology
MRM: Mutual Regulation Model
MRSS: Maternal Regulatory Scoring System
NOS: Newcastle-Ottawa Scale
PPD: Postpartum Depression
PPA: Postpartum Anxiety
PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses
SCID: Structural Clinical Interview for the Diagnostic and Statistical Manual of Mental Disorders
SPSS: Statistical Package for the Social Sciences

Declaration of Academic Achievement

The thesis is presented in a sandwich style as contained manuscripts are submitted or prepared for submission to peer-review journals. The contribution of each author of each manuscript is described below.

Chapter Two: Study One

Article title: The Influence of Maternal Postpartum Depression and/or Anxiety on Mother-Infant Performance on The Face-to-Face Still-face Task: A Systematic Review and Meta-Analysis

Authors: Kwadjo O. Ntow

Contribution: Kwadjo O. Ntow formulated the research question, wrote the review protocol, developed the search strategy in consultation with a librarian and screened study titles, abstracts and full texts for eligibility. Kwadjo also extracted data, performed analyses, and wrote the first draft of the manuscript. Kwadjo was assisted by trained undergraduate and graduate students in the Van Lieshout lab at screening and data-extraction stages. The manuscript of this study is currently being prepared for submission to a peer-review journal.

Chapter Three: Study Two

Article title: Maternal and Infant Performance on the Face-to-Face Still-Face Task following Maternal Cognitive Behavioral Therapy for Postpartum Depression

Authors: Kwadjo O. Ntow, John E. Krzeczkowski, Bahar Amani, Calan D. Savoy, Louis A. Schmidt, Ryan J. Van Lieshout.

CHAPTER ONE: GENERAL INTRODUCTION

Postpartum Depression and Postpartum Anxiety

Postpartum depression (PPD) is one of the most common complications following birth and affects around 17% of women in the first year after delivery (Shorey et al., 2018). The most common symptoms of PPD are low mood, anhedonia, irritability, anxiety, low self-esteem, hopelessness and problems with concentration and decision-making (Zadeh et al., 2012). These symptoms can negatively impact the quality of life, interpersonal relationships, and the psychological health of mothers (Slomian et al., 2019). Mothers with PPD are also more likely to develop chronic mood and anxiety problems beyond the postpartum period (Prenoveau et al., 2013; Vliegen et al., 2013). Further, PPD is linked to lower levels of family cohesion (Taylor & Johnson, 2013), and mothers with severe PPD are more likely to have fewer functioning social relationships (Dagher et al., 2014; Posmontier, 2008) and higher rates of suicidal thoughts and self-harm (Do et al., 2013; Pope et al., 2013). Although maternal PPD is the most commonly studied maternal mental health problem following delivery, postpartum anxiety (PPA) has also been identified as a common complication, affecting 13%-40% of all mothers (Farr et al., 2014; Field, 2017; Howard et al., 2018; C. Reck et al., 2008; Ross & McLean, 2006; Wenzel et al., 2005). Furthermore, PPA is a common comorbidity of PPD, and studies have suggested that mothers suffering from both experience even worse outcomes than PPD or PPA alone (Carter et al., 2001; Field et al., 2010).

Impact on the Mother-Infant Relationship

PPD and/or PPA can also have adverse effects on mother-infant relationships in the short- and long-term (C. T. Beck, 2001; Corinna Reck et al., 2018; Slomian et al., 2019). Maternal PPD and PPA can impact mother-infant interactions (Kingston et al., 2018), which is thought to be one of the mechanisms underlying the intergenerational transmission of depression and anxiety from women to their infants (de Rosnay et al., 2006; Madden et al., 2015; Moehler et al., 2006). Mothers with PPD and PPA display less positive parenting behaviours, which may affect the quality of interaction within the dyad, and is highlighted by more disengagement and hostility, respectively, towards their infants (Field, 2010; E. Tronick & Reck, 2009). This lack of mother-infant mutual regulation and coordination during interactions is associated with lower levels of maternal warmth (Lilja et al., 2012; Mitchell et al., 2019) and sensitivity (Lanzi et al., 2009; Logsdon et al., 2006). Together, these factors impact mother-infant attachment and bonding, resulting in less favourable mother-infant relationships and infant outcomes across the lifespan (M.P. & K.A., 2008; Murray et al., 2006; S. Hairston et al., 2018; Toth et al., 2009).

Impact on Infants

Research has suggested that maternal PPD and PPA negatively impacts infant development as the infants of mothers with PPD and/or PPA have been shown have more cognitive (Azak, 2012), emotional (Feldman et al., 2009), and behavioural problems (Kalita, 2010; Murray et al., 2007) compared to the infants of non-depressed and non-anxious mothers. Concerning emotional and behavioural challenges, maternal PPD has consistently been found to be associated with more difficult temperaments (Hanington et al., 2010) and insecure attachment (Toth et al., 2009) in infants. Furthermore, both maternal PPD and PPA has been linked to poor

academic achievement (Piteo et al., 2012) and a higher risk of poor interpersonal functioning and mood disorders such as depression and anxiety in childhood and adolescence (Beardslee et al., 1998; Weissman et al., 1987).

The Mutual Regulation Model

The mutual regulation model (MRM) has been proposed to describe and understand the underlying phenomenon of how mothers scaffold their infants' emotions and assist in making meaning of their surroundings (Gianino & Tronick, 1988). The MRM explains the process of maternal facilitation of infants' awareness and perception of people, relationships and themselves, and is one of the core mechanisms explaining infant and child socio-emotional development (Gianino & Tronick, 1988). According to the MRM, mother-infant interactions are bilaterally coordinated via affective reciprocity. Two states can be achieved during a dyadic interaction: affective matching and mismatching. Affective matching is described as moments in which mothers and their infants share the same affect (e.g., positive maternal engagement coupled with positive infant engagement). Conversely, affective mismatching occurs when mothers are displaying a different affect compared to their infants (e.g., positive maternal engagement coupled with negative infant engagement). Using behavioural cues and signals from the infants, mothers may adapt their behaviour in different scenarios accordingly, which leads to a high level of coordination during interactions (E. Z. Tronick & Gianino, 1986).

It should be noted that mother-infant interactions are not always perfect and affective mismatching is the norm rather than the exception. However, in healthy mother-infant dyads, mothers help repair affective mismatches into positive matches by modifying their behaviours using their infants' communicative cues. These repairs lead to a sense of infant control and

3

adequacy and subsequently influences the development of adaptive self-regulatory responses (E. Z. Tronick & Gianino, 1986). Unfortunately, in dyads exposed to PPD and/or PPA, mothers appear to be less aware of the behavioural cues displayed by their infants and sometimes fail to respond appropriately. PPD may affect mothers' ability to engage with their infants since mothers may be less responsive during interactions, leading to more affective mismatches without reparations (E. Tronick & Reck, 2009). Conversely, mothers with PPA tend to be more intrusive and hostile toward their infants' activities during face-to-face interactions (Murray et al., 2007; E. Tronick & Reck, 2009). Mothers' compromised ability to engage with their infants could result in a domino effect of a series of fewer positive interactions and produce a cycle of negative affect (E. Tronick & Reck, 2009), a risk factor for the development of mental health problems later in life.

The Face-to-Face Still-Face Task

The face-to-face still-face (FFSF) task is a robust and widely used observational task used to examine mother-infant interactions, infant self-regulation and infant stress-reactivity (E. Tronick et al., 1978). The standard FFSF task consists of three phases, including the play, sill-face, and reunion phases, which are all two minutes long. During the play phase, mothers are instructed to interact with their infants as they usually would at home without the use of toys. At the still-face, mothers keep a 'poker' face while looking at their infants, without touching them. During the reunion phase, mothers begin to interact with their infants again as they did in the play phase. The FFSF task is underlined by the still-face effect, which is characterized by considerable changes in infant behaviour and affect across FFSF phases. In general, during the still-face phase, infants gaze at their mothers less and display more negative behaviours like

4

protesting and withdrawn behaviour compared to the play and reunion phases (Mesman et al., 2009). In addition to this, infants show significantly more negative responses and less positive behaviour at the reunion phase compared to the play phase. This phenomenon is known as the carry-over effect and has also been consistently found in many studies with wide ranges of samples (Koester, 1995; Koester & Meadow-Orlans, 1999; Nagy et al., 2017; Weinberg et al., 2008).

The play phase of the FFSF task serves as an interactive baseline period primarily used to evaluate the quality of interactions between mothers and their infants (E. Tronick et al., 1978). The still-face phase is used to measure infants' reactivity to a stressful state and self-regulation as mothers are unavailable emotionally and are characterized by higher mother-infant affective mismatching. The reunion phase allows mothers and infants to reconcile and move towards a state of positive affective matching, and mother and infant behaviour during this phase characterize their capacity to cope with distress and mutually regulate their emotions (Mesman et al., 2009).

Studies have shown that mothers with PPD and/or PPA and their infants may respond differently to the FFSF task compared to non-depressed mothers and their infants. Generally, the infants of mothers with PPD display more negative affect at the play and reunion phases, accompanied by lower levels of positive affect compared to the infants of healthy mothers (Field et al., 2007; Katherine Weinberg et al., 2006; Mesman et al., 2009; E. Tronick & Reck, 2009; Vieites & Reeb-Sutherland, 2017). Nevertheless, the distinction between the two groups during the still-face phase is less apparent and uncertain, as different studies have found mixed results. Some studies have indicated that infants exposed to maternal PPD exhibit reduced distress and

negative affect at the still-face phase (Field et al., 2007; Forbes et al., 2004). Likewise, a

systematic review and meta-analysis revealed that the infants of mothers with PPD show more

positive affect at still-face only (Graham et al., 2018). Other studies have further found no

significant differences between the infants of mothers with PPD and those of healthy control

mothers at the still-face phase (G. A. Moore et al., 2001; Peláez-Nogueras et al., 1996; Stanley et

al., 2004). In reference to PPA, the infants of mothers diagnosed with PPA may exhibit

significantly lower levels of positive affect during the play phase versus the infants of healthy

controls. Also, the infants of mothers with PPA show significantly less protesting behaviour

during the still-face phase, while showing more protesting behaviour during the reunion phase

compared to the infants of healthy non-anxious mothers (Corinna Reck et al., 2018). While many

studies have focused on infant response to the FFSF in the context of exposure to maternal

depression, some studies have also analyzed maternal performance. There appears to be a

significant correlation between maternal depression and negative maternal behaviour on the

FFSF task (Field et al., 2007; Rosenblum et al., 2002; Stanley et al., 2004). However, the results

of some studies also point toward the lack of a significant difference between mothers with PPD

or PPA versus healthy mothers in maternal behaviour (Corinna Reck et al., 2011, 2018; Vieites

& Reeb-Sutherland, 2017). Altogether, these mixed findings highlight the uncertainty and gaps

in knowledge within the FFSF task literature, emphasizing the importance of an updated

synthesis, and a clear and concise summary of FFSF outcomes for both PPD and PPA.

Cognitive Behavioural Therapy for Maternal Postpartum Depression

When undiagnosed or inadequately treated, PPD can have detrimental effects not only on

mothers and their infants but the entire family (Campbell & Cohn, 1997; Horowitz & Goodman,

6

2004). The most effective treatments for PPD are evidence-based psychotherapies like

interpersonal psychotherapy (IPT) or cognitive behavioural therapy (CBT) (Butler et al., 2006;

Chabrol et al., 2002; Huang et al., 2018; Murray et al., 2003; Sockol et al., 2011) and anti-

depressants (Zheng et al., 2019). However, women prefer IPT and CBT when available

(Driessen & Hollon, 2010; Van Schaik et al., 2004). CBT is a problem-focused treatment that

relies on the conception that one's emotions and behaviours stem from one's thoughts. The goal

of CBT for maternal PPD is to help affected women avoid negative thoughts, thus translating

into more positive feelings and attitudes (Ammerman et al., 2013; A. T. Beck, 1997). Although

CBT is typically administered in an individual setting, a growing body of empirical research

indicates that group CBT may be as effective as individualized CBT in lowering maternal

depressive symptoms (Goodman & Santangelo, 2011; Scope et al., 2013; Stevenson et al., 2010;

Van Lieshout et al., 2017). Moreover, group CBT is resource-efficient, reduces waitlists, may

serve as a source of social support (Van Lieshout et al., 2017), and has the potential to be a cost-

effective and first-line psychotherapy for PPD, reducing the burden on mothers, families and the

healthcare system.

Rationale and Objectives

Due to gaps in knowledge in the influence of maternal psychopathology (PPD and/or PPA)

on FFSF outcomes, the first aim of this thesis was to examine the impact of PPD, PPA, and

comorbid PPD and PPA on infant, maternal and mother-infant dyadic behaviour by performing a

systematic review and meta-analysis. Although the FFSF task is a widely used and validated

research instrument with several important outcomes, no studies have examined the influence of

PPA and comorbid PPD and PPA on infant, maternal and dyadic FFSF performance. The

rationale behind conducting the systematic review and meta-analysis was to effectively synthesize available data from studies examining the influence of maternal PPD, PPA and comorbid PPD and PPA, when compared to healthy dyads on mother, infant and dyadic performance on the FFSF task.

The second goal of this thesis is to investigate whether group CBT can help reduce maternal depressive symptomatology and subsequently improve mother and infant FFSF outcomes. Due to the efficacy and effectiveness of group CBT, it was hypothesized that nine weeks of CBT treatment for PPD would lower maternal PPD scores and simultaneously alter mother and infant behaviour after treatment. We tested this hypothesis by assessing mother and infant behavioural outcomes using the FFSF task at three timepoints: before maternal CBT treatment for PPD, immediately after treatment, and three months post-treatment. Control mother-infant dyads consisted of non-depressed mothers and were also assessed on the same timeline as the PPD group.

The following chapters include two studies that were undertaken to help reach the overall goals of this thesis. Chapter two of this document presents a systematic review and meta-analysis titled "The influence of maternal postpartum depression and/or anxiety on infant performance on the face-to-face still face task: A systematic review and meta-analysis." This is a draft of a prepared manuscript to be submitted for publication in a peer-review journal. The next section contains the primary empirical research titled "Maternal and Infant Performance on the Face-to-Face Still-Face Task following Maternal Cognitive Behavioral Therapy for Postpartum Depression." This work will be submitted to the *Journal of Affective Disorders* for review and publication.

CHAPTER TWO: STUDY ONE

THE INFLUENCE OF MATERNAL POSTPARTUM DEPRESSION AND/OR ANXIETY

ON MOTHER-INFANT PERFORMANCE ON THE FACE-TO-FACE STILL-FACE TASK: A

SYSTEMATIC REVIEW AND META-ANALYSIS

Abstract

Objective: The face-to-face still-face (FFSF) task is a widely used measure of mother-infant mutual regulation, consisting of play, still-face and reunion phases. This systematic review and meta-analysis aimed to examine the differences in mother-infant behavioural responses to the FFSF task in mothers diagnosed with postpartum depression (PPD), postpartum anxiety (PPA), or comorbid PPD and PPA and their infants, and compare these to healthy control dyads.

Methods: A literature search was conducted in PubMed/MEDLINE, EMBASE, CINAHL, PsycINFO and Web of Science up to January 2020. A random-effects model was employed, and a standardized mean difference (SMD) was used to quantify outcomes. The Newcastle-Ottawa Scale was used to assess the risk of bias of include studies.

Results: 11 studies were included in the review, and five were eligible for meta-analyses. The infants of mothers with PPD display significantly lower levels of positive affect at play (SMD: -0.30, 95% confidence interval [CI]: -0.51,-0.08) and reunion (SMD: -0.23, 95% CI: -0.44, -0.01) compared to the infants of healthy control mothers. Mothers with PPD engage less positively with their infants at the reunion phase (SMD: -0.72, 95% CI: -1.26, -0.18) compared to non-depressed mothers, and mother-infant dyads affected by PPD show less positive interactive matching at the play phase compared to healthy control dyads (SMD: -0.62, 95% CI: -0.82,0.18). Finally, object/environment engagement was higher in infants of PPA mothers compared to healthy controls at still-face (SMD: 0.41, 95% CI: 0.16,0.67).

Conclusion: Although few studies were included in the review, it appears that maternal diagnosis of PPD and/or PPA may negatively affect infant, maternal and mother-infant dyadic FFSF performance. Future research should employ an experimental design and samples involving mothers with comorbid PPD and PPA.

Introduction

Postpartum depression (PPD) is a common mental health complication in the first year after delivery and affects approximately 17% of mothers (Beck, 2001; Gavin et al., 2005; Shorey et al., 2018). Apart from the personal suffering that PPD causes mothers by affecting their thoughts, attitudes, and functioning, it has compromising effects on the mother-infant relationship (Cooper et al., 1999; Murray et al., 2003; Paris et al., 2009; Righetti-Veltema et al., 2002; E. Tronick & Reck, 2009). PPD may impact infant development and contribute to the increased rates of emotional, behavioural and school problems seen in the offspring of affected mothers (Carter et al., 2001; Leiferman, 2002; O'Hara & McCabe, 2013; Rouse & Goodman, 2014; M. Katherine Weinberg & Tronick, 1998). Although PPD has been the focal point of research involving the effect of maternal postpartum mood disorders on infant outcomes, a growing body of work has recently been focused on other harmful complications like postpartum anxiety (PPA) (Farr et al., 2014; T. Field, 2017; C. Reck et al., 2008; Ross & McLean, 2006; Wenzel et al., 2005). The prevalence of PPA in mothers ranges from 13% to 40% and is characterized by persistent distress, worrying, restlessness, poor functioning and parenting problems (Farr et al., 2014; T. Field, 2017; Howard et al., 2018; C. Reck et al., 2008). Like PPD, maternal PPA is associated with less optimal socio-emotional, language and cognitive

development in the infants of affected mothers. Moreover, considerable comorbidity has also been noted between PPD and PPA (up to 52% comorbidity rate) (Andrews et al., 2000; Dennis et al., 2018; C. Reck et al., 2008), potentially leading to even worse outcomes for both mothers and their infants (Carter et al., 2001; T. Field et al., 2010).

Mother-infant mutual regulation during face-to-face interactions has been thought to be one of the key processes predicting both adaptive and maladaptive behavioural infant outcomes (Beeghly & Tronick, 1994; Gianino & Tronick, 1988; E. Z. Tronick & Weinberg, 1997). Healthy, non-depressed mothers may rely on their infants' communicative signals to facilitate their emotional regulation through more positive engagements. Unfortunately, mothers with PPD and/or PPA may be less capable of noticing infant behavioural cues to respond appropriately. Specifically, mothers with PPD are less responsive to their infants and their activities during dyadic social interactions (Mesman et al., 2009; E. Tronick & Reck, 2009). This lack of mutual regulation between mothers with PPD and their infants may lead to more infant negative affect, predominantly withdrawn behaviour (T. Field et al., 1988; Rouse & Goodman, 2014; E. Tronick & Reck, 2009). Conversely, mothers with PPA are more likely to display intrusive and hostile behaviours and actively interfere with the activities of their infants during face-to-face interactions (Kaitz & Maytal, 2005; E. Tronick & Reck, 2009). The infants of mothers with PPA respond to this behaviour by displaying more negative affectivity, such as anger and protesting (E. Tronick & Reck, 2009). Importantly, infant negative affectivity has been linked with internalizing and externalizing problems (Gartstein et al., 2012; Putnam & Stifter, 2005), anger management problems (Rothbart et al., 2000) and mood disorders in childhood and adolescence

12

(Rubin et al., 2009), highlighting the importance of socio-emotional interactions between the mother-infant dyad in shaping behavioural outcomes much beyond infancy.

The face-to-face still-face (FFSF) task is a widely used and validated observational tool used to measure mother-infant socio-emotional interaction quality and regulation. The standard FFSFP consists of three sequential two-minute phases: play, still-face and reunion. During the play phase, mothers are instructed to interact with their infants as they normally would. Next, mothers are asked to keep a "poker"/expressionless face and not touch their infants during the still-face phase. Finally, at the reunion phase, mothers reinitiate playing with their infants as they did during the play phase (Mesman et al., 2009; E. Tronick et al., 1978). The FFSF task measures a wide array of specific infant, maternal and mother-infant dyadic outcomes. Primary infant outcomes on the FFSF task are positive affect, neutral affect, object/environment engagement and self-comforting behaviours, gaze aversion and negative affect., and maternal outcomes consist of positive affect, neutral affect and negative affect. Finally, common mother-infant dyadic outcomes are positive matching, affective mismatching, gaze synchrony, dyadic flexibility, repair latency, reparation rate, and latency to first match.

Only two previous systematic reviews and meta-analysis have been conducted on the FFSF task. While both reviews contributed to the field of developmental psychopathology by providing a synthesis of common FFSF outcomes for the infants of healthy mothers and those with PPD, gaps still remain (Graham et al., 2018; Mesman et al., 2009). The first review was published 11 years ago and primarily compared differences in infant responses to the FFSF task, in each phase (i.e., play vs. still-face, play vs. reunion and still-face vs. reunion). They also

conducted a subgroup analysis on the impact of maternal depression on infant responses to the

FFSF task in comparison to the infants of healthy control mothers (Mesman et al., 2009). The

second study focused on differences in infant response to the FFSF task, comparing the infants of

mothers with a lifetime or current diagnosis of PPD and the infants of healthy control mothers

(Graham et al., 2018). Although the FFSF task measures infant, maternal and mother-infant

dyadic outcomes, both reviews focused on a limited number of infant outcomes (i.e., positive

affect, neutral affect, gaze aversion and negative affect). Moreover, they included studies that

adopted modifications to the FFSF task, introducing significant procedural variations in their

meta-analyzed studies. Also, despite its importance, high prevalence, and high comorbidity with

PPD, no review has examined the impact of PPA on infant, maternal and dyadic behaviour

outcomes, or how common comorbidity between with PPD and PPA (Dennis et al., 2018; T.

Field et al., 2010; Navarro et al., 2008; Prenoveau et al., 2017; Ramakrishna et al., 2019; Stuart

et al., 1998), might influence these outcomes.

Given the increasing prevalence of maternal PPD, PPA and the comorbidity of PPD and

PPA and their adverse effects on mothers, and their infants' development, it is crucial to explore

the impact of all three of these on infant, maternal and mother-infant dyadic behavioural

outcomes. In this systematic review and meta-analysis, we compared behavioural responses on

the FFSF task between mothers with PPD, PPA and comorbid PPD and PPA (and their infants

and the mother-infant dyad) and healthy control dyads during each phase of the task. This study

could help identify available evidence on the potential consequences of maternal PPD and/or

PPA on a broader range of outcomes that were unavailable in previous reviews. We sought to

include the primary FFSF outcomes for infants, mothers and the mother-infant dyad. Infant outcomes analyzed were positive affect, neutral affect, object/environment engagement, self-comforting and negative affect, and maternal outcomes examined were positive affect, neutral affect and negative affect. Dyadic outcomes included positive matching, affective mismatching, dyadic flexibility, latency to first match, reparation rate and repair latency.

Methods

Search Strategy

A systematic search of Pubmed/MEDLINE, EMBASE, PsycINFO, CINAHL and Web of Science electronic databases was conducted from their inceptions to January 31, 2020. The search strategy centred around three concepts: face-to-face still-face task, postpartum depression and postpartum anxiety. Medical subheadings and keywords were used in searches when applicable. Keywords were developed in consultation with a research librarian to ensure that the search was inclusive and specific. After the initial search, more potentially relevant articles were retrieved by hand-searching the reference lists of studies eligible for full-text screening, as well as the two previous systematic reviews (Graham et al., 2018; Mesman et al., 2009).

Eligibility Criteria

Randomized control trials and observational studies (cross-sectional, cohort, case-control) were included if they examined the impact of maternal PPD and/or PPA on infant (up to 12 months old), maternal, or mother-infant dyadic FFSF performance. Studies were also

included if they were written in or translated to English. In terms of the FFSF procedure, studies that contained at least a play phase and still-face phase, without the use of toys or any form of maternal interaction (at the still-face phase) were included. Studies that contained a separation period (i.e., when mothers are instructed to leave the room for an extended period) were excluded since this poses more stress for infants and may interfere with the effect of the FFSF (T. Field et al., 2007; T. M. Field, 1991). Similarly, studies were also excluded if the task was not administered in a laboratory setting (e.g., performed in at home) since infants' familiarity with their surroundings may influence their performance on the FFSF task (Mesman et al., 2009). To identify the most rigorous evidence possible, studies published in non-peer-reviewed journals and grey literature were excluded from the review.

Data Extraction

Five trained independent reviewers screened all the titles, abstracts and full texts of potentially relevant records for eligibility, using the pre-defined inclusion and exclusion criteria. Each study was screened by a minimum of two reviewers, and any disagreements regarding the relevance of a study were discussed and resolved with an independent reviewer. The Cochrane-approved Covidence ® online tool was used for screening. Five individuals extracted study methodology, participant demographics, postpartum depression and or anxiety diagnosis, healthy control group information, FFSF procedural variations and timing (number of months postpartum) measurements into an Excel file, which were piloted with five randomly selected studies. Study authors were contacted through email if any study data were unclear, not meta-analyzable, or missing.

Data were extracted for infant FFSF outcomes, which included positive affect, neutral affect, object/environment engagement, self-comforting behaviours, gaze aversion and negative affect. Infant positive affect is characterized by joyous facial expressions (e.g., smiling or smirking) and vocalizations like babbling or laughing toward their mother. Neutral affect occurs when infants look towards their mothers and in the absence of positive or negative affect. Object/environment engagement is described as infants looking toward or interacting with objects or their surroundings, including their seat, clothing, wall, or a camera. Infant self-comforting behaviours include infant self-soothing activities such as sucking of the thumb, or clothing and clasping their hands. Gaze aversion is characterized by infants looking away from their mothers, while not necessarily focusing on an object or their surroundings. Lastly, infant negative affect is defined as displays of negative facial expressions (e.g., anger, fear, sadness, withdrawn, distress) or whimpering, fussiness and crying vocalizations (Izard et al., 1980; Mesman et al., 2009; Reck, C., Noe, D., and Cenciotti, 2008; E. Tronick et al., 1978; M. K. Weinberg et al., 1999; Yoo & Reeb-Sutherland, 2013).

Maternal FFSF outcomes to be extracted were positive affect, neutral affect and negative affect. Maternal positive affect is marked by smiles, laughter, play faces, or singing. Next, maternal neutral affect is described as mothers paying attention to their infants' activities without showing a positive or negative affect. Finally, negative affect is exemplified by maternal intrusiveness, hostility, or withdrawn behaviour towards their infants, which includes facial expressions of anger and unresponsiveness (Reck, C., Noe, D., and Cenciotti, 2008).

The mother-infant dyadic outcomes extracted were positive matching, affective mismatching, gaze synchrony, dyadic flexibility, repair latency, reparation rate, and latency to first match. Positive matching is defined as simultaneous displays of infant and mother positive affect during social engagements (Katherine Weinberg et al., 2006; Corinna Reck et al., 2011; M. Katherine Weinberg et al., 2008). In contrast, mismatching marks simultaneous displays of infant positive affect and negative maternal affect, or vice versa. Mother-infant dyadic gaze synchrony is identified by sustained gaze at their partner's face (Lotzin et al., 2015; M. Katherine Weinberg et al., 2008). Dyadic flexibility evaluates the capacity of mother-infant pairs to correct uncoordinated affective states through responsive adaptations (Lunkenheimer et al., 2011; Sravish et al., 2013). The reparation rate measures the change from a mismatching state to a matching state (absolute frequency/phase). Repair latency describes the average time it takes to achieve a positive matching state after affective mismatching. Latency to first match is the average time required by dyads to attain their first positive matching in the play and reunion phases (Muller et al., 2015; Corinna Reck et al., 2011).

Methodological Bias Assessment of Studies

The risk of bias was independently assessed using the Newcastle Ottawa Scale (NOS) for case-control and cohort studies and an adapted version of the NOS was also used to determine the quality of one cross-sectional study.

Statistical Analyses

A meta-analysis was performed when two or more independent studies reported on a specific outcome measure. A random-effects model was used in the meta-analyses. Effect sizes were expressed as standardized mean differences (SMDs) with 95% confidence intervals (CI). The Higgins I^2 statistic was used to determine the extent of variation (statistical heterogeneity) between effect estimates (0% to 100%), with an $I^2 \geq 75\%$ classified as considerable heterogeneity ("Cochrane Handb. Syst. Rev. Interv.," 2019),

Subgroup analyses were planned in advance and included the assessment of the impact of maternal education, socioeconomic status (SES), sexual abuse history, marital status, infant sex, gestational age (e.g., pre-term vs., full-term) and infant temperament on infant, maternal and mother-infant dyadic performance on the FFSF. All analyses were conducted using RevMan® 5.3.

Results

Study Selection

We identified a total of 983 potentially relevant records for title and abstract screening (826 from a database search, and an additional 157 from hand-searching). After removal of duplicates, we screened 540 studies,11 of which met study eligibility criteria. (See Fig. 1). Inter-rater reliability was high for the full-text screening (Cohen's $\kappa = 0.78$). Out of the eleven eligible studies, five contained data that could be meta-analyzed as the other six either did not have a comparison group, outcomes comparable to another study, or report data in a form that could be meta-analyzed. The remaining six studies are described in a narrative synthesis below.

Figure 1: PRISMA Flowchart for the systematic literature search
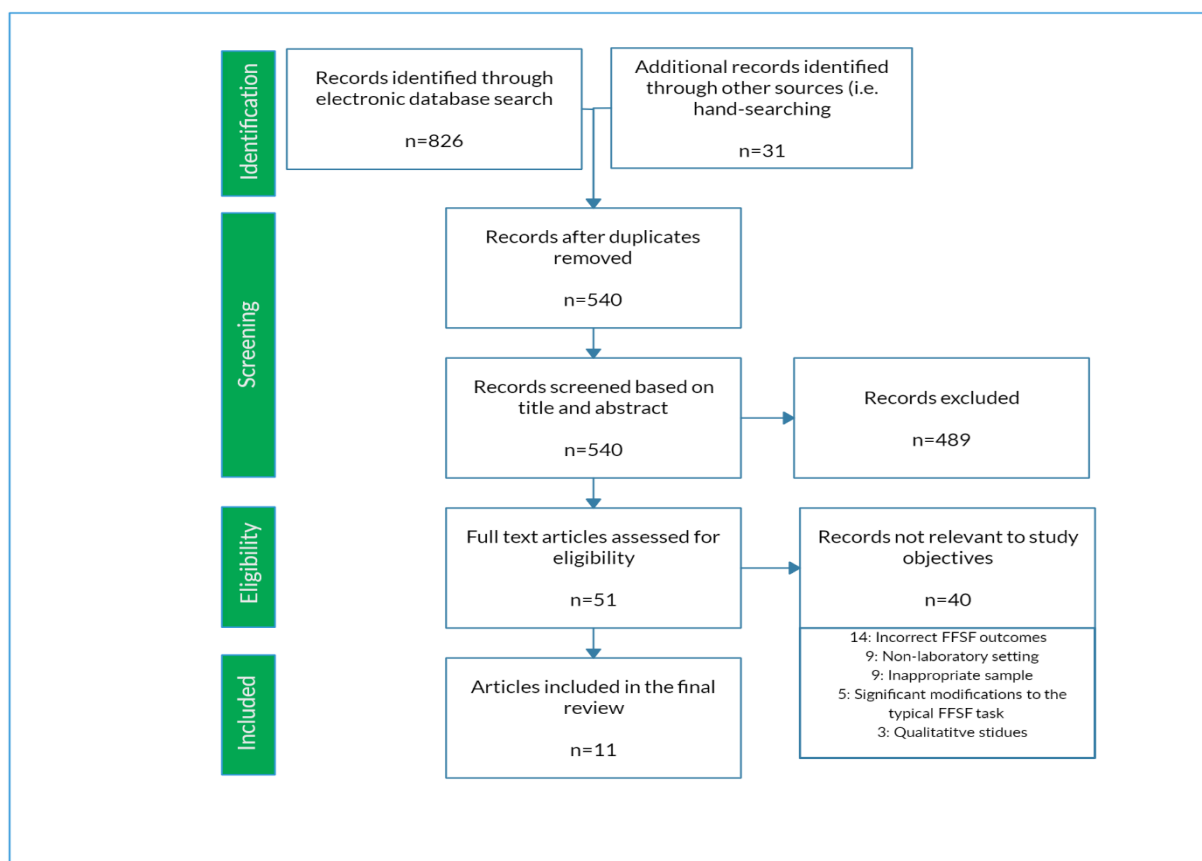
Characteristics of Included Studies

Participants characteristics

In total, 1,008 mother-infant dyads were assessed across 11 studies. These included 293 mothers with PPD and their infants, 173 mothers with PPA and their infants, 68 mothers with comorbid PPD and PPA, and their infants, and 474 healthy control dyads. The average infant age

across studies was 3.9 months. Table 1 contains a summary of the characteristics of the included studies.

Study characteristics

There were six cohort studies, four case-control studies, and one cross-sectional study with no control group. The studies were conducted in Germany (n=8), USA (n=2) and Canada (n=1). In total, eight studies assessed the influence of maternal PPD on FFSF performance. PPD was measured in three of the studies using the Structured Clinical Interview for DSM (SCID) (Lotzin et al., 2015; Corinna Reck et al., 2011; M. Katherine Weinberg et al., 2008), and one using the Composite International Diagnostic Interview (CIDI) (Asselmann et al., 2018) to define PPD. The remaining studies used either the Center for Epidemiological Studies Depression Scale (CES-D), the Beck Depression Inventory (BDI or BDI-II), or the Edinburgh Postnatal Depression Scale (EPDS) (Jung et al., 2007; Katherine Weinberg et al., 2006; Sravish et al., 2013; Vieites & Reeb-Sutherland, 2017). The clinical cut-points used to define PPD for each questionnaire scale can be found in Table 1. Four studies examined the impact of PPA on mother-infant FFSF task performance, and all used the SCID to define maternal PPA (Muller et al., 2015, 2016; Corinna Reck et al., 2018; M. Katherine Weinberg et al., 2008). Specific diagnoses from the SCID categorized under PPA were generalized anxiety disorder, panic disorder, obsessive compulsory disorder, agoraphobia, social phobia, specific phobia, post-traumatic stress disorder, and phobia not otherwise specified according to DSM-IV.

Six studies examined infant performance on the FFSF task across all three FFSF phases (two others only reported on the play and reunion phases), and three studies investigated maternal and dyadic outcomes in addition to this. For infants, FFSF behavioural outcomes examined included positive affect, neutral affect, object/environment engagement, self-comforting behavior, gaze aversion and negative affect. Potential maternal FFSF outcomes included positive affect and neutral affect. Six articles also examined the mother-infant dyad's performance, including positive matching, affective mismatching, gaze synchrony, dyadic flexibility, repair latency, reparation rate, and latency to first match.

Table 1: Characteristics of Included Studies

Author, year, country	Study design	Maternal diagnosis (measure)	Mean infant age	N[e]	FFSF protocol (or modification)	Phases Assessed	Outcomes	Scoring system	Risk of bias [d]
Asselmann et al., 2018, Germany	Cohort	PPD, PPA [a] and comorbid PPD & PPA [a] (CIDI-V)	4.0 months	251	Transition interval between play and still-face: mothers focused on a marked spot on the floor, counted to ten, and then faced a marked area on the wall above their infants [g]	All	Infant: Positive, negative affect, object engagement, self-comforting	ICEP, IRSS, AFFEX	Low
Lotzin et al., 2015, Germany	Cross-sectional	PPD [g] (SCID-DSM-IV)	6.3 months	68	Three-minute play and reunion; one-minute still-face	Play and reunion only	Dyad: Gaze synchrony	IRSS, MRSS	Low
Muller et al., 2015, Germany	Case-control	PPA [a] (SCID-DSM-IV)	3.3 months	46	Transition interval between play and still-face: mothers turned their head while silently counting to ten [g]	Play and reunion only	Dyad: Latency to repair	ICEP	Low
Muller et al., 2016, Germany	Case-control	PPA [a] (SCID-DSM-IV)	4.1 months	69	Transition interval between play and still-face: mothers turned their heads aside while silently counting to ten [g]	All	Infant: Self-comforting	ICEP	Low
Reck et al., 2011, Germany	Case-control	PPD [h] (both SCID-DSM-IV & ICD-10) [i,f]	3.9 months	62	Standard FFSF [g]	Play and reunion only	Dyad: Matching, reparation rate, repair latency, latency to first match	ICEP	Low
Reck et al., 2018, Germany	Case-control	PPA [a] (SCID)	4.1 months	87	Transition interval between the play and the following still-face: mothers turned their heads aside while counting quietly to ten [g]	All	Infant: Positive, negative, neutral affect & object engagement	ICEP	Low

							Mother: Positive, negative & neutral affect		
Sravish et al., 2013, Germany	Cohort	PPD (CES-D) Cut-off ≥ 16	3 months	124	Each phase separated by 15-second intervals during which the mother turned her back to the infant [g]	Play and reunion only	Dyad: Flexibility	AFFEX	Low
Vieitis et al., 2017, USA	Cohort	PPD (BDI)	5.1 months	63	Standard FFSF [g]	All	Infant: Positive, negative & neutral affect Mother: Positive & neutral affect	ICEP	Low
Weinberg et al., 2006, Germany	Cohort	PPD (CES-D) Cut-off ≥ 16	3.0 months	133	Each phase separated by 15- second intervals during which the mother turned her back to the infant [g]	Play and reunion only	Dyad: Matching, mismatching, synchrony, bidirectionality	AFFEX	Low
Weinberg et al., 2008, USA	Cohort	PPD [h] and PPA [c] (SCID)	3.0 months	94	Standard FFSF [g]	All	Infant & Mother: Positive affect, gaze aversion, object engagement, neutral affect Dyad: Matching, synchrony	IRSS, MRSS, AFFEX	Low
Jung et al., 2007, Canada	Cohort	PPD (EPDS/ BDI-II)	3.5 months	1 1	One-minute still-face phase [g]	All	Infant: Positive affect, negative affect, neutral affect	AFFEX	High

Studies were arranged according to their risk of bias and quality assessment
[a]: Panic disorder, agoraphobia, social phobia, specific phobia, generalized anxiety disorder, obsessive-compulsive disorder, posttraumatic stress disorder and phobia not otherwise specified according to DSM-IV
[b]: Two minutes per each phase
[c]: Panic disorder
[d]: Based on the Newcastle-Ottawa Scale
[e]: The sample size of mother-infant dyads
[f]: Administered by a psychiatrist
[g]: Major depressive disorder and dysthymia in the first 12 months
[h]: Major depressive disorder in the first 12 months
[i]: 9 mothers with PPD were diagnosed using the ICD-10 and 19 using the SCID-DSM-IV
AFFEX: System for Identifying Affect Expressions by Holistic Judgements
BDI: Beck Depression Inventory
CES-D: Center for Epidemiologic Studies Depression Scale
EPDS: Edinburgh Postnatal Depression Scale
ICD-10: International Classification of Diseases- Tenth Edition
ICEP: Infant Caregiver Engagement Phases
IRSS: Infant Regulatory Scoring System
MRSS: Maternal Regulatory Scoring System
SCID: Structured Clinical Interview for DSM

Risk of Bias and Quality Assessment

Of the 11 studies, one was rated as having a high risk of bias (score ≤ 4 on the NOS), while ten were scored as being at low risk (see Table 2). The study with a high risk of bias contained no control group, had a small sample size and lacked a representative sample (Jung et al., 2007). With the exception of one study (Lotzin et al., 2015), all the studies had a low risk of

selection bias, and four scored relatively low on the ascertainment of exposure/ outcome category (Jung et al., 2007; Katherine Weinberg et al., 2006; Sravish et al., 2013; M. Katherine Weinberg et al., 2008).

Table 2: Newcastle-Ottawa Scale for risk of bias assessment

Study	Selection	Comparability	Exposure / Outcome	Total	Risk of Bias
Cohort studies					
Asselmann 2018	★★★★	N/A	★★	6	Low
Sravish 2013	★★★	★★	★	6	Low
Vieites 2017	★★★	★★	★★	7	Low
Weinberg 2006	★★	★★	★	5	Low
Weinberg 2008	★★★★	★★	★	7	Low
Jung 2007	★		★	2	High
Case-control studies					
Muller 2015	★★★★	★★	★★	8	Low
Muller 2016	★★	★★	★★	6	Low
Reck 2011	★★	★★	★★	6	Low
Reck 2018	★★★	★★	★★	7	Low
Cross-sectional studies					
Lotzin 2015	★	★★	★★	5	Low

Newcastle-Ottawa Scale score ≤ 4 signifies a high risk of bias

Publication Bias

The funnel plots and Egger test for funnel plot asymmetry were not employed since all analyses consisted of fewer than ten studies. When this is the case, real symmetry cannot be reliably differentiated from spurious findings ("Cochrane Handb. Syst. Rev. Interv.," 2019; Sterne et al., 2011).

Meta-Analysis and Narrative Synthesis

In total, 25 different meta-analyses were performed using available data from five studies (Asselmann et al., 2018; Katherine Weinberg et al., 2006; Corinna Reck et al., 2011, 2018; Vieites & Reeb-Sutherland, 2017). The infant FFSF behavioural outcomes that were available for meta-analysis were positive affect, negative affect, neutral affect, and object/environment engagement during the play, still-face and reunion phases. Maternal behavioural outcomes available for meta-analysis included positive affect and neutral affect. In terms of dyadic outcomes, data were only available for mother-infant positive matching.

Mothers with Postpartum Depression: Infant Outcomes

Infant positive affect: Five studies contained data on maternal PPD and infant positive affect, and four of these were eligible for meta-analysis (Asselmann et al., 2018; Katherine Weinberg et al., 2006; Corinna Reck et al., 2011; Vieites & Reeb-Sutherland, 2017). It should be noted that two of these studies reported on the play and reunion phases only. The analysis showed that, at the play phase, infants of mothers with PPD displayed lower levels of positive affect (SMD: -0.30, 95% confidence interval [CI]: -0.51 to -0.08, *p*<0.01) (See Fig. 2). However, there were no significant differences between the two groups at the still-face phase (SMD: -0.18, 95% CI: -0.14 to 0.50) (See Fig. A in the Supplement). Also, at the reunion phase, the infants of mothers with PPD displayed lower levels of positive affect (SMD: -0.23, 95% CI: -0.44 to -0.01, *p*=0.04) compared to the infants of healthy control mothers (See Fig. 3). Only one study (M.

Katherine Weinberg et al., 2008) found no statistically significant differences in positive affect at any phase of the FFSF when a PPD group and a healthy control group were compared.

Figure 2: Forest plot for comparison between infants of mothers with PPD and infants of healthy controls infant positive affect at the play phase

	PPD			Healthy				Std. Mean Difference	Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random, 95% CI
Asselmann 2018	0.1	0.08	33	0.13	0.15	76	27.6%	-0.22 [-0.63, 0.19]	
Reck 2011	0.04	0.53	28	0.09	0.12	34	18.5%	-0.13 [-0.64, 0.37]	
Vieites 2017	0.18	0.11	33	0.21	0.11	30	18.8%	-0.27 [-0.77, 0.23]	
Weinberg 2006	0.084	0.083	45	0.14	0.14	88	35.1%	-0.45 [-0.81, -0.09]	
Total (95% CI)			139			228	100.0%	-0.30 [-0.51, -0.08]	

Heterogeneity: Tau² = 0.00; Chi² = 1.22, df = 3 (P = 0.75); I² = 0%
Test for overall effect: Z = 2.69 (P = 0.007)

Higher in [Healthy]   Higher in [PPD]
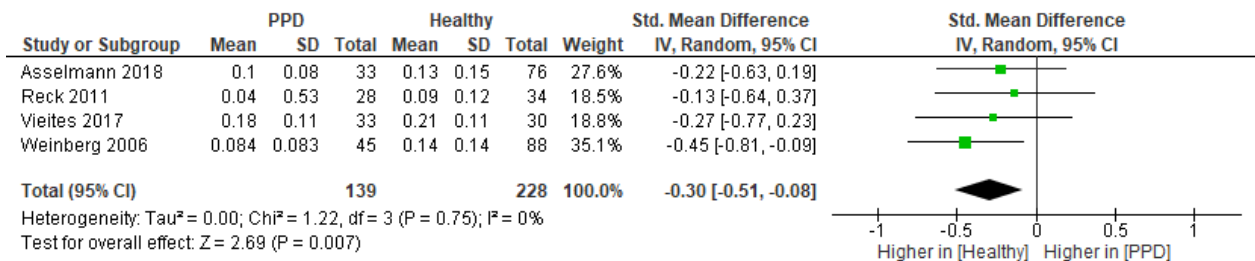
Figure 3: Forest plot for comparison between infants of mothers with PPD and infants of healthy controls infant positive affect at the reunion phase

	PPD			Healthy				Std. Mean Difference	Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random, 95% CI
Asselmann 2018	0.12	0.15	33	0.12	0.14	76	27.7%	0.00 [-0.41, 0.41]	
Reck 2011	0.05	0.05	28	0.08	0.17	34	18.4%	-0.23 [-0.73, 0.27]	
Vieites 2017	0.2	0.17	33	0.23	0.16	30	18.8%	-0.18 [-0.67, 0.32]	
Weinberg 2006	0.073	0.078	45	0.124	0.133	88	35.1%	-0.43 [-0.79, -0.07]	
Total (95% CI)			139			228	100.0%	-0.23 [-0.44, -0.01]	

Heterogeneity: Tau² = 0.00; Chi² = 2.44, df = 3 (P = 0.49); I² = 0%
Test for overall effect: Z = 2.07 (P = 0.04)

Higher in [Healthy]   Higher in [PPD]
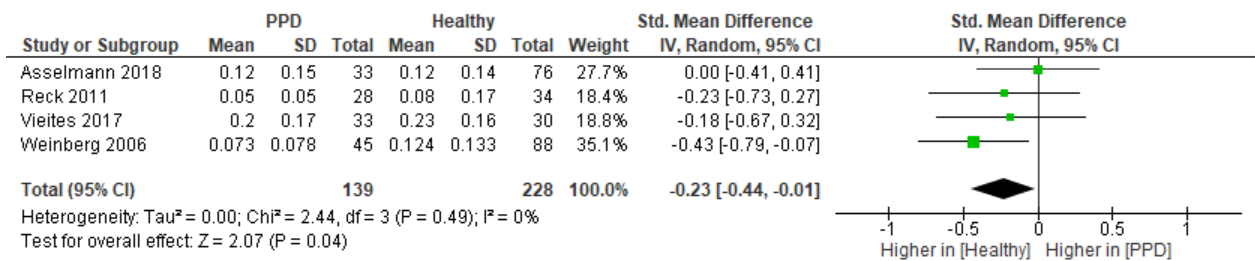
Infant neutral affect: The meta-analysis of three studies (Katherine Weinberg et al., 2006; Corinna Reck et al., 2011; Vieites & Reeb-Sutherland, 2017) showed no statistically significant differences between infants of mothers with PPD and infants of healthy controls at play (SMD: -0.20, 95% CI: -0.52 to 0.12) and reunion (SMD: -0.47, 95% CI: -1.09 to 0.14) (See Fig. B & C in the Supplement). No data were available for the still-face phase. However, Weinberg (2008) found that female, but not male, infants of mothers with PPD showed less neutral affect during

the across the play and reunion phases of the FFSF than did female infants of healthy mothers (M. Katherine Weinberg et al., 2008). No other studies were available for narrative synthesis.

Infant object/environment engagement: Two studies (Asselmann et al., 2018; Corinna Reck et al., 2011) contained data for maternal PPD and infant object/environment engagement during the play and reunion phases, which were included in the meta-analysis. The results showed that there were no statistically significant differences between the infants of mothers with PPD and the infants of non-depressed mothers at the play (SMD: 0.30, 95% CI: -0.02 to 0.62) or reunion (SMD: 0.16, 95% CI: -0.16 to 0.48) phases (See Fig. D & E).

Infant self-comforting behaviour: One study (Asselmann et al., 2018) investigated the impact of the maternal PPD on infant self-comforting behaviour at all three phases of the FFSF task. They identified that there were no differences between the two groups at any of the FFSF phases.

Gaze aversion: None of the studies included in the review contained data for gaze aversion.

Infant negative affect: Five studies examined the influence of maternal PPD on infant negative affect, and four had data available for meta-analysis (two reported data for the play and reunion phases only) (Asselmann et al., 2018; Katherine Weinberg et al., 2006; Corinna Reck et al., 2011; Vieites & Reeb-Sutherland, 2017). No statistically significant differences were found between the infants of mothers with PPD versus the infants of healthy controls at the play (SMD:

-0.03, 95% CI: -0.28 to 0.21), still-face (SMD: -1.57, 95% CI: -4.05 to 0.91), or reunion (SMD: 0.11, 95% CI: -0.13 to 0.35) phases were noted (See Fig. F, G & H in the Supplement).

Other results: Jung (2007) used the FFSF task to assess infant (3 months old) behaviour before and after the 5-week Keys to Caregiving intervention for mothers with PPD and found that the infants had higher levels of positive and negative affect after treatment at the reunion phase but not at the play or still-face phase (Jung et al., 2007). However, these results should be interpreted with caution since the study lacked a control group and examined just 11 mothers and their infants.

Mothers with Postpartum Depression: Maternal Outcomes

Maternal positive affect: The meta-analysis of three studies (Katherine Weinberg et al., 2006; Corinna Reck et al., 2011; Vieites & Reeb-Sutherland, 2017) revealed that there were no differences in positive maternal affect between mothers with PPD and healthy control mothers at the play phase (SMD: -1.13, 95% CI: -2.53 to 0.26) (See Fig. I in the Supplement). However, mothers with PPD engaged less positively with their infants (SMD: -0.72, 95% CI: -1.26 to -0.18, $p<001$) (See Fig. 4) at the reunion phase.

Figure 4: Forest plot for comparison between mothers with PPD and healthy controls infant

positive affect at the reunion phase
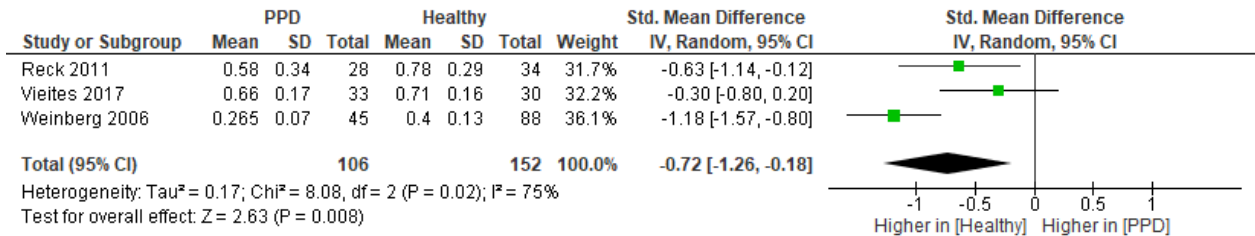
Maternal neutral affect: Three studies (Katherine Weinberg et al., 2006; Corinna Reck et al., 2011; Vieites & Reeb-Sutherland, 2017) contained data eligible for meta-analysis for maternal neutral affect. These studies showed no statistically significant differences at both the play and reunion phases (See Fig. J & K in the Supplement).

Maternal negative affect: None of the studies included in the systematic review examined differences in negative maternal affect between mothers with PPD and healthy control mothers on the FFSF task.

Mothers with Postpartum Depression: Mother-Infant Dyad Outcomes

Dyadic positive matching: Two studies (Katherine Weinberg et al., 2006; Corinna Reck et al., 2011) examined mother-infant positive matching, and a meta-analysis of these studies indicated that dyads consisting of mothers with PPD and their infants showed less positive matching compared to healthy control dyads during the initial play phase (SMD: -0.62, 95% CI: -0.92 to -0.32, $p<0.001$) (See Fig. 5) but, no differences were observed at the reunion phase (SMD: -0.32, 95% CI: -0.82 to 0.19) (See Fig. L in the Supplement).

Figure 5: Forest plot for comparison between PPD dyads and healthy control dyads of positive matching at the play phase
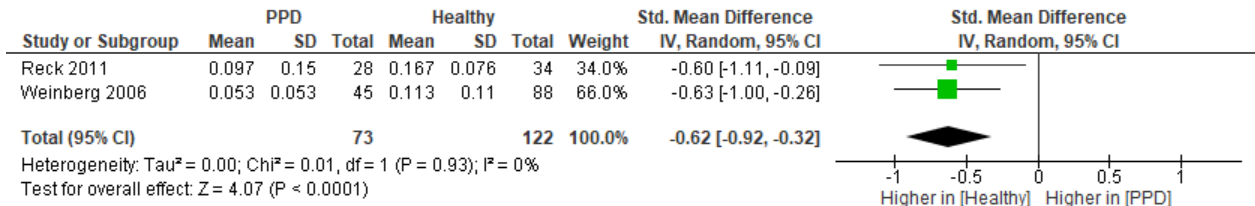
Dyadic mismatching: One study (Katherine Weinberg et al., 2006) explored the influence of maternal PPD on mother-infant dyadic mismatching. Their findings suggested that dyads involving mothers with PPD did not significantly differ from healthy control dyads for mismatching at both the play and reunion phase.

Dyadic gaze synchrony: One study (Lotzin et al., 2015) that consisted of mothers with PPD (no control group) examined the impact of maternal PPD on mother-infant gaze synchrony. A time-series analysis revealed that maternal PPD was positively correlated with mother-infant gaze synchrony (i.e., higher depressive symptoms predicted more mother-infant gaze synchrony) at the play and reunion phases of the FFSF task (Lotzin et al., 2015).

Dyadic flexibility: Sravish et al. (2013) was the only study that investigated the effects of maternal PPD on mother-infant dyadic flexibility, and found no differences between PPD dyads and healthy control dyads (Sravish et al., 2013). However, analysis stratified by infant sex suggested that dyads involving mothers with maternal PPD and their male infants were less flexible and that these infants displayed significantly higher infant negativity during the still-face episode than male infants of healthy controls.

Reparation rate, repair latency & latency to first match: Reck (2011) was the only study in this review that examined the differences between dyads with depressed mothers and healthy control dyads in reparation rate, repair latency and latency to first match (Corinna Reck et al., 2011). They found that the rate of repairing mismatched dyadic states to matching states was significantly faster among PPD dyads compared to healthy control dyads in the reunion phase but not in the play phase of the FFSF task. In the play phase, dyads involving mothers with PPD took longer to repair mismatches into positive matches as compared with the control dyads. Lastly, their results indicated that, on average, during the first 3 seconds of the play and reunion phase, 50% of the healthy control dyads accomplished a positive matching state while it took PPD dyads 12 and 18 seconds, respectively, to achieve this. Their analysis revealed that these differences were statistically significant for both the play and reunion phases of the FFSF task (Corinna Reck et al., 2011).

Mothers with Postpartum Anxiety: Infant Outcomes

Infant positive affect: Two studies (Asselmann et al., 2018; Corinna Reck et al., 2018) examined infant positive affect in the infants of mothers with PPA and healthy control infants and both were eligible for a meta-analysis. There were no statistically significant differences between the infants of mothers with PPA and the infants of healthy controls at the play (SMD: -0.17, 95% CI: -0.55 to 0.21), still-face (SMD: 0.38, 95% CI: -0.39 to 1.16) and reunion (SMD: 0.17, 95% CI: -0.09 to 0.42) phases (See Fig. M, N & O in the Supplement)

Infant neutral affect: None of the studies included in this systematic review that contained data for infant neutral affect on the FFSF task among the offspring of mothers with PPA.

Infant object/environment engagement: Meta-analysis of two studies (Asselmann et al., 2018; Corinna Reck et al., 2018) showed that there were no differences in infant object/environment engagement at the play (SMD: 0.14, 95% CI: -0.13 to 0.42) and reunion (SMD: 0.07, 95% CI: -0.19 to 0.33) phases (See Fig. P & Q). However, at the still-face phase, object/environment engagement was higher in infants of PPA mothers compared to healthy controls (SMD: 0.41, 95% CI: 0.16 to 0.67, p=0.002) (See Fig. 6). No other studies included in the review investigated the impact of maternal PPA on infant object/environment engagement.

Figure 6: Forest plot for comparison between infants of mothers with PPA and infants of healthy controls infant object/environment engagement at the still-face phase
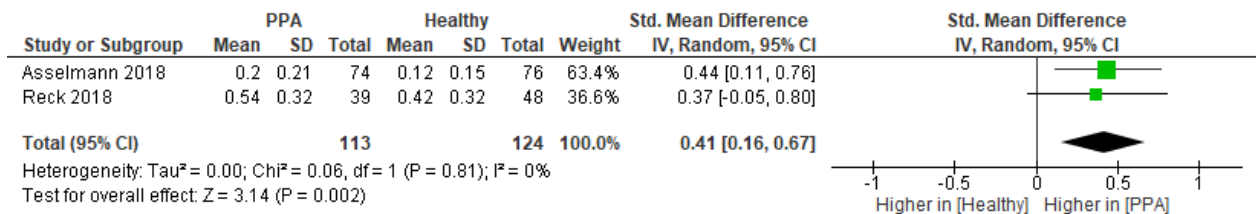
Infant self-comforting behaviour: Muller (2016) had a sample of mothers diagnosed with PPA using the SCID and their infants and healthy control dyads. They investigated the impact of maternal PPA on cumulative infant self-comforting behaviour across all FFSF phases (Muller et

al., 2016). They found that there was no significant correlation between maternal PPA and infant self-comforting behaviours.

Gaze aversion: None of the studies included in the review reported data for gaze aversion.

Infant negative affect: Two studies (Asselmann et al., 2018; Corinna Reck et al., 2018) were eligible for meta-analysis of this outcome and the results revealed no differences between infants exposed to maternal PPA and the infants of healthy control mothers at the play (SMD: -0.03, 95% CI: -0.68 to 0.63), still-face (SMD: -0.24, 95% CI: -0.50 to 0.01) or reunion (SMD: -0.08, 95% CI: -0.45 to 0.29) phases (See Fig. R, S & T in the Supplement)

Mothers with Postpartum Anxiety: Maternal Outcomes

Maternal positive affect, *neutral affect & negative affect:* None of the studies included in the review examined maternal FFSF outcomes in mothers with PPA.

Mothers with Postpartum Anxiety: Mother-Infant Dyad Outcomes

Dyadic positive matching, *mismatching*, *gaze synchrony*, *flexibility:* None of the studies containing a sample of mothers with PPA examined these mother-infant FFSF outcomes

Reparation rate, repair latency & latency to first match: Muller (2015) explored whether maternal PPA (diagnosed using the SCID-DSM-IV) had an impact on mother-infant repair latency. After comparing dyads consisting of mothers with PPA and healthy control dyads, their

analyses suggested that there were no differences between the groups in dyadic repair latency (Muller et al., 2015). No other studies examined the effects of maternal PPA on mother-infant dyadic reparation rate and latency to first match on the FFSF task.

Mothers with Comorbid Postpartum Depression and Anxiety: Infant Outcomes

Infant positive affect: Only one study (Asselmann et al., 2018) included in this review examined the influence of maternal comorbid PPD and PPA on infant (4 months old) positive affect. Their findings indicated that there were no statistically significant differences in positive affect between the infants of mothers with comorbid PPD and PPA and the infants of healthy control mothers at any of the FFSF phases.

Infant object/environment engagement: Asselmann et al., (2018) found that the infants of mothers with comorbid PPD and PPA showed a significantly higher proportion of object/environment engagement compared to the infants of healthy control mothers at the still-face (7.9% mean difference) and reunion (2.9% mean difference) phases, but not at the play phase.

Infant self-comforting behaviour: One study (Asselmann et al., 2018) examined the impact of maternal comorbid PPD and PPA on infant self-comforting behaviours during the FFSF task and found no statistically significant differences between the infants of mothers with comorbid PPD and PPA and healthy controls.

Infant negative affect: Asselmann et al., (2018) found that the infants of mothers with comorbid PPD and PPA did not statistically differ from the infants of healthy control mothers in this outcome during the play, still-face and reunion phases.

Mothers with Comorbid Postpartum Depression and Anxiety: Maternal Outcomes

Maternal positive affect, neutral affect and negative affect: None of the studies included in this review examined the influence of PPA on maternal FFSF outcomes.

Mothers with Comorbid Postpartum Depression and Anxiety: Mother-Infant Dyad Outcomes

Dyadic positive matching, *mismatching*, *gaze synchrony*, *flexibility:* None of the studies included in this review investigated the effect of maternal PPA on dyadic FFSF outcomes

Reparation rate, repair latency & latency to first match: None of the studies included in this review examined the impact of maternal PPA on dyadic FFSF outcomes.

Discussion

This study examined the influence of PPD, PPA, and comorbid PPD and PPA on infant, maternal and mother-infant dyadic performance on the FFSF task. The results of the systematic review and meta-analysis suggest that the infants of mothers with PPD may engage less positively with their mothers on the FFSF at both play and reunion phases. Also, mothers with PPD appear to engage less positively with their infants at the reunion phase, and dyads containing mothers with PPD and their infants display less positive matching in the play phase.

These meta-analyses were complemented by the findings of the narrative synthesis, which indicated that the female infants of women with PPD might display more neutral affect versus their male counterparts. Further, dyads involving mothers with maternal PPD and their female infants appear to be less flexible during dyadic face-to-face interactions, and these infants displayed higher infant negativity during the still-face phase than the male infants of healthy control mothers. These results illustrate that mothers with PPD, their infants and mother-infant dyads may struggle more to achieve positive, fluid interactions during the FFSF task compared to healthy control dyads. Next, the infants of mothers with PPA may engage more with objects and their environment at the still-face phase, suggesting that these infants are more attuned to regulating their own emotions when their mothers are affectively unavailable, due to their familiarity with this situation from prior mother-infant interactions. Finally, the infants of mothers with comorbid PPD and PPA appear to show more object/environment engagement compared to the infants of healthy control mothers at the still-face and reunion phases. Again, this may signify infant self-regulation in the absence of maternal regulation, which, in this specific case, extends into the reunion phase, meaning that the infants of mothers with comorbid PPD and PPA may have a higher propensity to depend on themselves for emotion regulation compared to PPA only. It should be noted that the review contained 11 studies, with six examining just PPD exposure, three PPA, one PPD and PPA, and one PPD, PPA and comorbid PPD and PPA.

The result suggesting that the infants of mothers with PPD may display less positive affect at the play and reunion phases, but not at the still-face phase, complements a previous

systematic review that found no differences between both groups across all phases of the FFSF task in their meta-analysis (Mesman et al., 2009). Also, though we found no statistically significant differences, Graham et al., (2018) discovered that the infants of mothers with PPD exhibit higher levels of positive affect, at the still-face phase only, compared to the infants of healthy control mothers. These differences may be because the previous review included records with procedural differences to the FFSF task, such as the addition of a 'separation' phase before the still-face phase and the administration of the FFSF task at a home setting. Such changes to the standard FFSF protocol may impact the infant performance on the FFSF task. For instance, physical separation of mothers from their infants has been thought an immensely stressful circumstance for their infants (T. Field et al., 2007; T. M. Field, 1991), which may compound the stress the still-face phase poses. Further, the administration of the FFSF task at home may influence responses due to familiarity with that specific setting (Mesman et al., 2009). Overall, it appears that our better adherence to the standard FFSF protocol and inclusion of studies conducted in a controlled laboratory setting may explain the differences in the results.

The meta-analyses suggest that infants of mothers with PPD display less positive affect at the play and reunion phases. Positive affect during face-to-face mother-infant interactions is important in evaluating the quality of interactions, serving as a key element in infant socio-emotional development (Cohn & Tronick, 1987; Forbes et al., 2004). The increased presence of infant positive affect may be a result of predictable and flexible maternal behaviours during face-to-face interactions (Cohn & Elmore, 1988; Skotheim et al., 2013). However, studies have shown that mothers with PPD may be less able to effectively engage with their infants predictably and

sensitively to elicit more positive emotions from their infants (Brummelte & Galea, 2016; E. Tronick & Reck, 2009). Therefore, lower levels of maternal sensitivity in mothers with PPD may explain the lower levels of their infants' positive affect, compared to the infants of healthy control mothers at the play and reunion phases. Indeed, it appears that maternal PPD may affect positive maternal interactive behaviours on the FFSF task since we also found that mothers with PPD showed less positive affect at the reunion phase of the FFSF task. Moreover, the meta-analysis suggests that mother-infant positive matching (a measure of simultaneous display of positive affect from mothers and their infants) was lower in PPD dyads compared to healthy control dyads. This result indicates that maternal PPD may also affect the coordination of the mother-infant dyad. Therefore, it appears that maternal PPD negatively impacts maternal sensitivity during mother-infant engagements, potentially leading to fewer positive behaviours in the mothers themselves, their infants, and the mother-infant dyad during face-to-face interactions on the FFSF task.

We also found that the infants of mothers with PPA may engage more with objects and their surroundings compared to the infants of healthy control mothers at the still-face phase. This may be because the infants of mothers with PPA depend more on self-regulation and interact with their environments as a coping strategy (Manian & Bornstein, 2009). It appears that these infants are accustomed to maternal affective unavailability and resort to independent regulatory behaviours when their mothers are unavailable at the still-face phase.

The synthesis revealed that the infants of mothers with comorbid PPD and PPA might interact more with objects and their environment compared to the infants of healthy controls at

the still-face and reunion phases. This result may indicate that the infants of mothers with comorbid PPD and PPA also exhibit self-regulatory behaviours in the absence of maternal regulation during the still-face phase. However, these infants also appear to show a significantly higher proportion of object/environment engagement at the reunion phase as well, signifying a carry-over of infant self-regulation from still-face to reunion. This difference shows that comorbid PPD and PPA potentially have a more substantial effect on infant object/environment engagement than PPA alone, which may be attributed to the higher severity of comorbid maternal PPD and PPA (Biederman et al., 1991; Rosenbaum et al., 1988) compared to PPA alone.

However, the meta-analyses between PPD dyads and healthy control dyads revealed no statistically significant differences in infant neutral affect, object/environment engagement, self-comforting behaviours and negative affect in addition to maternal neutral affect and negative affect on the FFSF task. Further, there were no differences in dyadic mismatching, gaze synchrony, flexibility, reparation rate, repair latency and latency to first match. The lack of statistically significant findings for these FFSF outcomes is unclear. Nonetheless, these could be because of the few studies included in the meta-analyses in addition to relatively small sample sizes of these studies (underpowered effects). It is also possible that the FFSF task is not able to differentiate between mothers with PPD (their infants, and the mother-infant dyad) and healthy control dyads in these specific FFSF outcomes (Stanley et al., 2004).

Similarly, no differences were found in infant positive affect, neutral affect, self-comforting behaviours and negative affect, between the infants of mothers with PPA and the

infants of healthy control mothers. In addition to the small studies and sample sizes examined, the heterogeneity within the diagnoses of women categorized under PPA (e.g., generalized anxiety disorder, panic disorder, obsessive-compulsive disorder, post-traumatic stress disorder and social phobia) may also be responsible for obscuring statistically significant findings. Studies have proposed that the impact of maternal PPA on mother-infant behaviours differs according to the sub-type of anxiety disorder (de Rosnay et al., 2006; Murray et al., 2012).

This review has some limitations which should be noted. First, one of the studies had a high risk of bias, which introduced methodological heterogeneity and may impact the overall strength and certainty of the evidence (Viswanathan et al., 2008). Second, due to the relatively small number of studies on the FFSF task and maternal PPD and/or PPA, only eleven studies were included in the review, six of which did not report meta-analyzable data. Finally, there are inconsistent uses of the FFSF task, with some studies adopting variations of the task, which could affect the accuracy of the pooled estimates derived from the meta-analyses (Melsen et al., 2014).

Future studies should focus on using adequately large sample sizes and analyze the influence of comorbid PPD and PPA on infant, maternal and mother-infant FFSF outcomes. Furthermore, when possible, studies using the FFSF task to examine the effect of maternal PPA and the mother-infant relationship should test for the possible effects of specific anxiety disorder subtypes in order to parse out specific effects. Also, we found that no studies investigated the potential moderating effects of factors other than infant sex on FFSF outcomes. Such moderators include infant gestational age and temperament as well as a maternal history of sexual abuse,

marital status and socioeconomic status. Finally, future studies should also adopt experimental designs that test for the effectiveness of interventions for the mother-infant relationship, using the FFSF task due to its validity and robustness.

Overall, this review helps highlight the potentially maladaptive effect that maternal psychopathology may have on mother-infant relationships, and subsequently, infant socio-emotional development, and may help inform future studies that aim to understand or mitigate the impact of PPA and/or PPA on behavioural outcomes. The results provide evidence to suggest that the FFSF task is useful in understanding the effects of maternal PPD and/or PPA on mother-infant relationships. Future studies should implement experimental designs and focus more on the influence comorbid PPD and PPA on infant, maternal and dyadic FFSF behavioural outcomes.

Acknowledgments

We would like to thank Zoe Tsai, Katie Huh, Marina Shaker and Kesidha Raajakesary.

References

Andrews, G., Sanderson, K., Slade, T., & Issakidis, C. (2000). Why does the burden of disease persist? Relating the burden of anxiety and depression to effectiveness of treatment. *Bulletin of the World Health Organization*. https://doi.org/10.1080/000486700536

Asselmann, E., Venz, J., Wittchen, H.-U., & Martini, J. (2018). Maternal anxiety and depressive disorders prior to, during and after pregnancy and infant interaction behaviors during the Face-to-Face Still Face Task at 4 months postpartum: A prospective-longitudinal study. *Early Human Development*, *122*, 45–53. https://doi.org/https://dx.doi.org/10.1016/j.earlhumdev.2018.05.007

Beck, C. T. (2001). Predictors of postpartum depression: An update. *Nursing Research*. https://doi.org/10.1097/00006199-200109000-00004

Beeghly, M., & Tronick, E. Z. (1994). Effects of prenatal exposure to cocaine in early infancy: Toxic effects on the process of mutual regulation. *Infant Mental Health Journal*. https://doi.org/10.1002/1097-0355(199422)15:2<158::AID-IMHJ2280150207>3.0.CO;2-7

Biederman, J., Newcorn, J., & Sprich, S. (1991). Comorbidity of attention deficit hyperactivity disorder with conduct, depressive, anxiety, and other disorders. *American Journal of Psychiatry*, *148*(5), 564–577. https://doi.org/10.1176/ajp.148.5.564

Brummelte, S., & Galea, L. A. M. (2016). Postpartum depression: Etiology, treatment and consequences for maternal care. *Hormones and Behavior*.

https://doi.org/10.1016/j.yhbeh.2015.08.008

Carter, A. S., Garrity-Rokous, F. E., Chazan-Cohen, R., Little, C., & Briggs-Gowan, M. J. (2001). Maternal depression and comorbidity: Predicting early parenting, attachment security, and toddler social-emotional problems and competencies. *Journal of the American Academy of Child and Adolescent Psychiatry*, *40*(1), 18–26. https://doi.org/10.1097/00004583-200101000-00012

Cochrane Handbook for Systematic Reviews of Interventions. (2019). In *Cochrane Handbook for Systematic Reviews of Interventions*. https://doi.org/10.1002/9781119536604

Cohn, J. F., & Elmore, M. (1988). Effect of contingent changes in mothers' affective expression on the organization of behavior in 3-month-old infants. *Infant Behavior and Development*. https://doi.org/10.1016/0163-6383(88)90008-2

Cohn, J. F., & Tronick, E. Z. (1987). Mother-Infant Face-to-Face Interaction: The Sequence of Dyadic States at 3, 6, and 9 Months. *Developmental Psychology*. https://doi.org/10.1037/0012-1649.23.1.68

Cooper, P. J., Tomlinson, M., Swartz, L., Woolgar, M., Murray, L., & Molteno, C. (1999). Post-partum depression and the mother-infant relationship in a South African peri-urban settlement. *British Journal of Psychiatry*. https://doi.org/10.1192/bjp.175.6.554

de Rosnay, M., Cooper, P. J., Tsigaras, N., & Murray, L. (2006). Transmission of social anxiety from mother to infant: An experimental study using a social referencing task. *Behaviour*

Research and Therapy. https://doi.org/10.1016/j.brat.2005.09.003

Dennis, C. L., Brown, H. K., Wanigaratne, S., Fung, K., Vigod, S. N., Grigoriadis, S., Marini, F., & Brennenstuhl, S. (2018). Prevalence, Incidence, and Persistence of Postpartum Depression, Anxiety, and Comorbidity among Chinese Immigrant and Nonimmigrant Women: A Longitudinal Cohort Study. *Canadian Journal of Psychiatry*. https://doi.org/10.1177/0706743717720689

Farr, S. L., Dietz, P. M., O'Hara, M. W., Burley, K., & Ko, J. Y. (2014). Postpartum anxiety and comorbid depression in a population-based sample of women. *Journal of Women's Health*. https://doi.org/10.1089/jwh.2013.4438

Field, T. (2017). Postpartum Anxiety Prevalence, Predictors and Effects on Child Development: A Review. *Journal of Psychiatry and Psychiatric Disorders*. https://doi.org/10.26502/jppd.2572-519x0010

Field, T., Diego, M., Hernandez-Reif, M., Figueiredo, B., Deeds, O., Ascencio, A., Schanberg, S., & Kuhn, C. (2010). Comorbid depression and anxiety effects on pregnancy and neonatal outcome. *Infant Behavior and Development*. https://doi.org/10.1016/j.infbeh.2009.10.004

Field, T., Healy, B., Goldstein, S., Perry, S., Bendell, D., Schanberg, S., Zimmerman, E. A., & Kuhn, C. (1988). Infants of Depressed Mothers Show "Depressed" Behavior Even with Non-depressed Adults. *Child Development*. https://doi.org/10.2307/1130671

Field, T., Hernandez-Reif, M., Diego, M., Feijo, L., Vera, Y., Gil, K., & Sanders, C. (2007).

Still-face and separation effects on depressed mother-infant interactions. *Infant Mental Health Journal*. https://doi.org/10.1002/imhj.20138

Field, T. M. (1991). Young Children's Adaptations to Repeated Separations from Their Mothers. *Child Development*. https://doi.org/10.2307/1131129

Forbes, E. E., Cohn, J. F., Allen, N. B., & Lewinsohn, P. M. (2004). Infant affect during parent-infant interaction at 3 and 6 months: Differences between mothers and fathers and influence of parent history of depression. *Infancy*. https://doi.org/10.1207/s15327078in0501_3

Gartstein, M. A., Putnam, S. P., & Rothbart, M. K. (2012). Etiology of preschool behavior problems: Contributions of temperament attributes in early childhood. *Infant Mental Health Journal*. https://doi.org/10.1002/imhj.21312

Gavin, N. I., Gaynes, B. N., Lohr, K. N., Meltzer-Brody, S., Gartlehner, G., & Swinson, T. (2005). Perinatal Depression: A Systematic Review of Prevalence and Incidence. *Obstetrics & Gynecology*, *106*(5), 1071–1083. https://doi.org/10.1097/01.AOG.0000183597.31630.db

Gianino, A., & Tronick, E. Z. (1988). The mutual regulation model: The infant's self and interactive regulation and coping and defensive capacities. In *Stress and coping across development.* (pp. 47–68). Lawrence Erlbaum Associates, Inc.

Graham, K. A., Blissett, J., Antoniou, E. E., Zeegers, M. P., McCleery, J. P., K.A., G., J., B., E.E., A., & M.P., Z. (2018). Effects of maternal depression in the Still-Face Task: A meta-analysis. *Infant Behavior and Development*, *50*, 154–164.

https://doi.org/http://dx.doi.org/10.1016/j.infbeh.2017.12.001

Howard, L. M., Ryan, E. G., Trevillion, K., Anderson, F., Bick, D., Bye, A., Byford, S.,

O'Connor, S., Sands, P., Demilew, J., Milgrom, J., & Pickles, A. (2018). Accuracy of the

Whooley questions and the Edinburgh Postnatal Depression Scale in identifying depression

and other mental disorders in early pregnancy. *British Journal of Psychiatry*.

https://doi.org/10.1192/bjp.2017.9

Izard, C. E., Huebner, R. R., Risser, D., & Dougherty, L. (1980). The young infant's ability to

produce discrete emotion expressions. *Developmental Psychology*.

https://doi.org/10.1037/0012-1649.16.2.132

Jung, V., Short, R., Letourneau, N., Andrews, D., V., J., R., S., & N., L. (2007). Interventions

with depressed mothers and their infants: Modifying interactive behaviours. *Journal of

Affective Disorders*, *98*(3), 199–205.

https://doi.org/http://dx.doi.org/10.1016/j.jad.2006.07.014

Kaitz, M., & Maytal, H. (2005). Interactions between anxious mothers and their infants: An

integration of theory and research findings. In *Infant Mental Health Journal*.

https://doi.org/10.1002/imhj.20069

Katherine Weinberg, M., Olson, K. L., Beeghly, M., & Tronick, E. Z. (2006). Making up is hard

to do, especially for mothers with high levels of depressive symptoms and their infant sons.

Journal of Child Psychology and Psychiatry, *47*(7), 670–683.

https://doi.org/10.1111/j.1469-7610.2005.01545.x

Leiferman, J. (2002). The effect of maternal depressive symptomatology on maternal behaviors associated with child health. *Health Education and Behavior*. https://doi.org/10.1177/109019802237027

Lotzin, A., Romer, G., Schiborr, J., Noga, B., Schulte-Markwort, M., & Ramsauer, B. (2015). Gaze Synchrony between Mothers with Mood Disorders and Their Infants: Maternal Emotion Dysregulation Matters. *PLoS ONE*. https://doi.org/10.1371/journal.pone.0144417

Lunkenheimer, E. S., Olson, S. L., Hollenstein, T., Sameroff, A. J., & Winter, C. (2011). Dyadic flexibility and positive affect in parent-child coregulation and the development of child behavior problems. *Development and Psychopathology*, *23*(2), 577–591. https://doi.org/10.1017/S095457941100006X

Manian, N., & Bornstein, M. H. (2009). Dynamics of emotion regulation in infants of clinically depressed and non-depressed mothers. *Journal of Child Psychology and Psychiatry and Allied Disciplines*. https://doi.org/10.1111/j.1469-7610.2009.02166.x

Melsen, W. G., Bootsma, M. C. J., Rovers, M. M., & Bonten, M. J. M. (2014). The effects of clinical and statistical heterogeneity on the predictive values of results from meta-analyses. In *Clinical Microbiology and Infection* (Vol. 20, Issue 2, pp. 123–129). Blackwell Publishing Ltd. https://doi.org/10.1111/1469-0691.12494

Mesman, J., van IJzendoorn, M. H., & Bakermans-Kranenburg, M. J. (2009). The many faces of

the Still-Face Task: A review and meta-analysis. *Developmental Review*, *29*(2), 120–162. https://doi.org/10.1016/j.dr.2009.02.001

Muller, M., Tronick, E., Zietlow, A.-L. L., Nonnenmacher, N., Verschoor, S., Trauble, B., M., M., E., T., A.-L., Z., N., N., S., V., Müller, M., Tronick, E., Zietlow, A.-L. L., Nonnenmacher, N., Verschoor, S., & Träuble, B. (2016). Effects of Maternal Anxiety Disorders on Infant Self-Comforting Behaviors: The Role of Maternal Bonding, Infant Gender and Age. *Psychopathology*, *49*(4), 295–304. https://doi.org/10.1159/000448404

Muller, M., Zietlow, A.-L., Tronick, E., Reck, C., M., M., A.-L., Z., & E., T. (2015). What Dyadic Reparation Is Meant to Do: An Association with Infant Cortisol Reactivity. *Psychopathology*, *48*(6), 386–399. https://doi.org/https://dx.doi.org/10.1159/000439225

Murray, L., Cooper, P. J., Wilson, A., & Romaniuk, H. (2003). Controlled trial of the short- and long-term effect of psychological treatment of post-partum depression. 2. Impact on the mother-child relationship and child outcome. *British Journal of Psychiatry*. https://doi.org/10.1192/bjp.182.5.420

Murray, L., Lau, P. Y., Arteche, A., Creswell, C., Russ, S., Zoppa, L. Della, Muggeo, M., Stein, A., & Cooper, P. (2012). Parenting by anxious mothers: Effects of disorder subtype, context and child characteristics. *Journal of Child Psychology and Psychiatry and Allied Disciplines*. https://doi.org/10.1111/j.1469-7610.2011.02473.x

Navarro, P., García-Esteve, L., Ascaso, C., Aguado, J., Gelabert, E., & Martín-Santos, R. (2008).

Non-psychotic psychiatric disorders after childbirth: Prevalence and comorbidity in a

community sample. *Journal of Affective Disorders*.

https://doi.org/10.1016/j.jad.2007.10.008

O'Hara, M. W., & McCabe, J. E. (2013). Postpartum Depression: Current Status and Future

Directions. *Annual Review of Clinical Psychology*. https://doi.org/10.1146/annurev-clinpsy-

050212-185612

Paris, R., Bolton, R. E., & Weinberg, M. K. (2009). Postpartum depression, suicidality, and

mother-infant interactions. *Archives of Women's Mental Health*.

https://doi.org/10.1007/s00737-009-0105-2

Prenoveau, J. M., Craske, M. G., West, V., Giannakakis, A., Zioga, M., Lehtonen, A., Davies,

B., Netsi, E., Cardy, J., Cooper, P., Murray, L., & Stein, A. (2017). Maternal postnatal

depression and anxiety and their association with child emotional negativity and behavior

problems at two years. *Developmental Psychology*. https://doi.org/10.1037/dev0000221

Putnam, S. P., & Stifter, C. A. (2005). Behavioral approach-inhibition in toddlers: Prediction

from infancy, positive and negative affective components, and relations with behavior

problems. *Child Development*. https://doi.org/10.1111/j.1467-8624.2005.00840.x

Ramakrishna, S., Cooklin, A. R., & Leach, L. S. (2019). Comorbid anxiety and depression: a

community-based study examining symptomology and correlates during the postpartum

period. *Journal of Reproductive and Infant Psychology*.

https://doi.org/10.1080/02646838.2019.1578870

Reck, C., Noe, D., and Cenciotti, F. (2008). *Infant and Caregiver Engagement Phases Revised (ICEP-R) Coding Manual*.

Reck, C., Struben, K., Backenstrass, M., Stefenelli, U., Reinig, K., Fuchs, T., Sohn, C., & Mundt, C. (2008). Prevalence, onset and comorbidity of postpartum anxiety and depressive disorders. *Acta Psychiatrica Scandinavica*. https://doi.org/10.1111/j.1600-0447.2008.01264.x

Reck, Corinna, Noe, D., Stefenelli, U., Fuchs, T., Cenciotti, F., Stehle, E., Mundt, C., Downing, G., Tronick, E. Z., C., R., D., N., U., S., T., F., F., C., E., S., C., M., & G., D. (2011). Interactive coordination of currently depressed inpatient mothers and their infants during the postpartum period. *Infant Mental Health Journal*, *32*(5), 542–562. https://doi.org/http://dx.doi.org/10.1002/imhj.20312

Reck, Corinna, Tietz, A., Müller, M., Seibold, K., & Tronick, E. (2018). The impact of maternal anxiety disorder on mother-infant interaction in the postpartum period. *PLoS ONE*, *13*(5). https://doi.org/10.1371/journal.pone.0194763

Righetti-Veltema, M., Conne-Perréard, E., Bousquet, A., & Manzano, J. (2002). Postpartum depression and mother-infant relationship at 3 months old. *Journal of Affective Disorders*. https://doi.org/10.1016/S0165-0327(01)00367-6

Rosenbaum, J. F., Biederman, J., Gersten, M., Hirshfeld, D. R., Meminger, S. R., Herman, J. B.,

Kagan, J., Reznick, J. S., & Snidman, N. (1988). Behavioral Inhibition in Children of

Parents With Panic Disorder and Agoraphobia: A Controlled Study. *Archives of General

Psychiatry*, *45*(5), 463–470. https://doi.org/10.1001/archpsyc.1988.01800290083010

Ross, L. E., & McLean, L. M. (2006). Anxiety disorders during pregnancy and the postpartum

period: A systematic review. *Journal of Clinical Psychiatry*.

https://doi.org/10.4088/JCP.v67n0818

Rothbart, M. K., Derryberry, D., & Hershey, K. (2000). Stability of temperament in childhood:

Laboratory infant assessment to parent report at seven years. In *Temperament and

personality development across the life span*.

Rouse, M. H., & Goodman, S. H. (2014). Perinatal depression influences on infant negative

affectivity: Timing, severity, and co-morbid anxiety. *Infant Behavior and Development*.

https://doi.org/10.1016/j.infbeh.2014.09.001

Rubin, K. H., Coplan, R. J., & Bowker, J. C. (2009). Social Withdrawal in Childhood. *Annual

Review of Psychology*. https://doi.org/10.1146/annurev.psych.60.110707.163642

Shorey, S., Chee, C. Y. I., Ng, E. D., Chan, Y. H., Tam, W. W. S., & Chong, Y. S. (2018).

Prevalence and incidence of postpartum depression among healthy mothers: A systematic

review and meta-analysis. *Journal of Psychiatric Research*, *104*(April), 235–248.

https://doi.org/10.1016/j.jpsychires.2018.08.001

Skotheim, S., Braarud, H. C., Høie, K., Markhus, M. W., Malde, M. K., Graff, I. E., Berle, J. Ø.,

& Stormark, K. M. (2013). Subclinical levels of maternal depression and infant sensitivity

to social contingency. *Infant Behavior and Development*.

https://doi.org/10.1016/j.infbeh.2013.03.009

Sravish, A. V, Tronick, E., Hollenstein, T., & Beeghly, M. (2013). Dyadic Flexibility during the

Face-to-Face Still-Face Task: A dynamic systems analysis of its temporal organization.

Infant Behavior & Development, *36*(3), 432–437.

https://doi.org/10.1016/j.infbeh.2013.03.013

Stanley, C., Murray, L., & Stein, A. (2004). The effect of postnatal depression on mother-infant

interaction, infant response to the Still-face perturbation, and performance on an

Instrumental Learning task. *Development and Psychopathology*, *16*(1), 1–18.

http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medc&NEWS=N&AN=1

5115062

Sterne, J. A. C., Sutton, A. J., Ioannidis, J. P. A., Terrin, N., Jones, D. R., Lau, J., Carpenter, J.,

Rücker, G., Harbord, R. M., Schmid, C. H., Tetzlaff, J., Deeks, J. J., Peters, J., Macaskill,

P., Schwarzer, G., Duval, S., Altman, D. G., Moher, D., & Higgins, J. P. T. (2011).

Recommendations for examining and interpreting funnel plot asymmetry in meta-analyses

of randomised controlled trials. *BMJ (Online)*. https://doi.org/10.1136/bmj.d4002

Stuart, S., Couser, G., Schilder, K., O'Hara, M. W., & Gorman, L. (1998). Postpartum anxiety

and depression: Onset and comorbidity in a community sample. *Journal of Nervous and

Mental Disease*. https://doi.org/10.1097/00005053-199807000-00006

Tronick, E., Als, H., Adamson, L., Wise, S., & Brazelton, T. B. (1978). The Infant's Response to Entrapment between Contradictory Messages in Face-to-Face Interaction. *Journal of the American Academy of Child Psychiatry*, *17*(1), 1–13. https://doi.org/10.1016/S0002-7138(09)62273-1

Tronick, E., & Reck, C. (2009). Infants of depressed mothers. *Harvard Review of Psychiatry*, *17*(2), 147–156. https://doi.org/10.1080/10673220902899714

Tronick, E. Z., & Weinberg, K. M. (1997). Depressed mothers and infants: Failure to form dyadic states of consciousness. In *Postpartum depression and child development*.

Vieites, V., & Reeb-Sutherland, B. C. (2017). Individual differences in non-clinical maternal depression impact infant affect and behavior during the still-face task across the first year. *Infant Behavior and Development*. https://doi.org/10.1016/j.infbeh.2017.02.005

Viswanathan, M., Ansari, M. T., Berkman, N. D., Chang, S., Hartling, L., McPheeters, M., Santaguida, P. L., Shamliyan, T., Singh, K., Tsertsvadze, A., & Treadwell, J. R. (2008). Assessing the Risk of Bias of Individual Studies in Systematic Reviews of Health Care Interventions. In *Methods Guide for Effectiveness and Comparative Effectiveness Reviews*. Agency for Healthcare Research and Quality (US). http://www.ncbi.nlm.nih.gov/pubmed/22479713

Weinberg, M. K., Tronick, E. Z., Cohn, J. F., & Olson, K. L. (1999). Gender differences in emotional expressivity and self-regulation during early infancy. *Developmental Psychology*.

https://doi.org/10.1037/0012-1649.35.1.175

Weinberg, M. Katherine, Beeghly, M., Olson, K. L., & Tronick, E. (2008). Effects of maternal

depression and panic disorder on mother-infant interactive behavior in the Face-to-Face

Still-Face task. *Infant Mental Health Journal*. https://doi.org/10.1002/imhj.20193

Weinberg, M. Katherine, & Tronick, E. Z. (1998). The impact of maternal psychiatric illness on

infant development. In *Journal of Clinical Psychiatry*.

Wenzel, A., Haugen, E. N., Jackson, L. C., & Brendle, J. R. (2005). Anxiety symptoms and

disorders at eight weeks postpartum. *Journal of Anxiety Disorders*.

https://doi.org/10.1016/j.janxdis.2004.04.001

Yoo, K., & Reeb-Sutherland, B. C. (2013). Effects of negative temperament on 5-month-old

infants' behavior during the still-face task. *Infant Behavior and Development*.

https://doi.org/10.1016/j.infbeh.2013.03.002

Supplemental Data

Figure A: Infant Positive Affect at the Still-Face Phase: Maternal PPD vs. Healthy Control Mothers
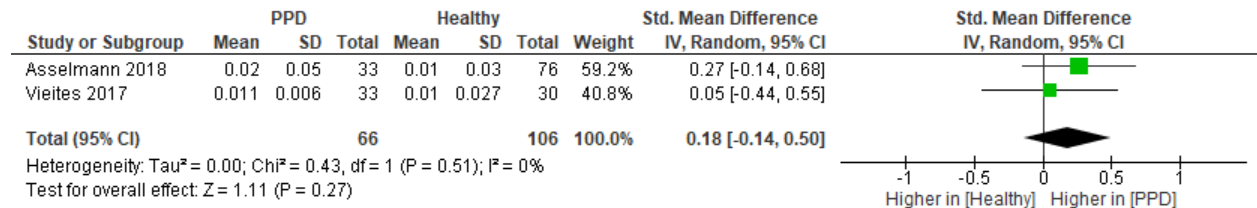
Figure B: Infant Neutral Affect at the Play Phase: Maternal PPD vs. Healthy Control Mothers

Figure C: Infant Neutral Affect at the Reunion Phase: Maternal PPD vs. Healthy Control Mothers
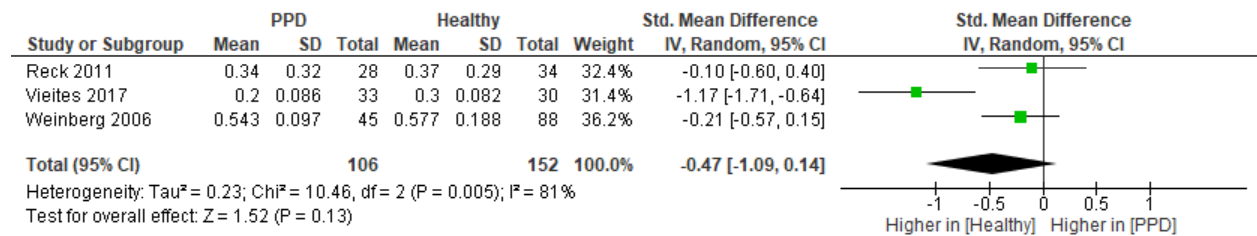
Figure D: Infant Object/Environment Engagement at the Play Phase: Maternal PPD vs.

Healthy Control Mothers

Figure E: Infant Object/Environment Engagement at the Reunion Phase: Maternal PPD

vs. Healthy Control Mothers

Figure F: Infant Negative Affect at the Play Phase: Maternal PPD vs. Healthy Control

Mothers

Figure G: Infant Negative Affect at the Still-Face Phase: Maternal PPD vs. Healthy Control Mothers

	PPD			Healthy				Std. Mean Difference	Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random, 95% CI
Asselmann 2018	0.15	0.28	33	0.26	0.36	76	50.7%	-0.32 [-0.73, 0.09]	
Vieites 2017	0.045	0.04	33	0.175	0.05	30	49.3%	-2.85 [-3.56, -2.14]	
Total (95% CI)			**66**			**106**	**100.0%**	**-1.57 [-4.05, 0.91]**	

Heterogeneity: Tau² = 3.11; Chi² = 36.23, df = 1 (P < 0.00001); I² = 97%
Test for overall effect: Z = 1.24 (P = 0.21)

Figure H: Infant Negative Affect at the Reunion Phase: Maternal PPD vs. Healthy Control Mothers

	PPD			Healthy				Std. Mean Difference	Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random, 95% CI
Asselmann 2018	0.17	0.31	33	0.19	0.32	76	27.4%	-0.06 [-0.47, 0.35]	
Reck 2011	0.16	0.26	28	0.13	0.24	34	19.6%	0.12 [-0.38, 0.62]	
Vieites 2017	0.085	0.035	33	0.065	0.04	30	19.4%	0.53 [0.02, 1.03]	
Weinberg 2006	0.23	0.19	45	0.24	11.36	88	33.5%	-0.00 [-0.36, 0.36]	
Total (95% CI)			**139**			**228**	**100.0%**	**0.11 [-0.13, 0.35]**	

Heterogeneity: Tau² = 0.01; Chi² = 3.68, df = 3 (P = 0.30); I² = 19%
Test for overall effect: Z = 0.88 (P = 0.38)

Figure I: Maternal Positive Affect at the Play Phase: Maternal PPD vs. Healthy Control Mothers

	PPD			Healthy				Std. Mean Difference	Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random, 95% CI
Reck 2011	0.49	0.26	28	0.66	0.26	34	33.2%	-0.65 [-1.16, -0.13]	
Vieites 2017	0.7	0.29	33	0.76	0.16	30	33.3%	-0.25 [-0.75, 0.25]	
Weinberg 2006	0.25	0.114	45	0.458	0.061	88	33.5%	-2.50 [-2.97, -2.03]	
Total (95% CI)			**106**			**152**	**100.0%**	**-1.13 [-2.53, 0.26]**	

Heterogeneity: Tau² = 1.45; Chi² = 47.82, df = 2 (P < 0.00001); I² = 96%
Test for overall effect: Z = 1.60 (P = 0.11)

57

Figure J: Maternal Neutral Affect at the Play Phase: Maternal PPD vs. Healthy Control Mothers

Study or Subgroup	PPD Mean	SD	Total	Healthy Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Reck 2011	0.42	0.26	28	0.27	0.23	34	32.7%	0.61 [0.09, 1.12]
Vieites 2017	0.31	0.14	33	0.27	0.13	30	32.9%	0.29 [-0.21, 0.79]
Weinberg 2006	0.089	0.054	45	0.162	0.099	88	34.3%	-0.84 [-1.21, -0.47]
Total (95% CI)			**106**			**152**	**100.0%**	**0.01 [-0.92, 0.93]**

Heterogeneity: Tau² = 0.61; Chi² = 24.47, df = 2 (P < 0.00001); I² = 92%
Test for overall effect: Z = 0.01 (P = 0.99)

Figure K: Maternal Positive Affect at the Reunion Phase: Maternal PPD vs. Healthy Control Mothers

Study or Subgroup	PPD Mean	SD	Total	Healthy Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Reck 2011	0.41	0.26	28	0.34	0.29	34	33.1%	0.25 [-0.25, 0.75]
Vieites 2017	0.38	0.17	33	0.33	0.16	30	33.1%	0.30 [-0.20, 0.80]
Weinberg 2006	0.086	0.055	45	0.21	0.1	88	33.8%	-1.41 [-1.81, -1.01]
Total (95% CI)			**106**			**152**	**100.0%**	**-0.30 [-1.47, 0.88]**

Heterogeneity: Tau² = 1.02; Chi² = 38.42, df = 2 (P < 0.00001); I² = 95%
Test for overall effect: Z = 0.49 (P = 0.62)

Figure L: Mother-Infant Positive Matching at the Reunion Phase: Maternal PPD vs. Healthy Control Mothers

Study or Subgroup	PPD Mean	SD	Total	Healthy Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Reck 2011	0.093	0.07	28	0.095	0.07	34	44.4%	-0.03 [-0.53, 0.47]
Weinberg 2006	0.046	0.051	45	0.098	0.11	88	55.6%	-0.55 [-0.91, -0.18]
Total (95% CI)			**73**			**122**	**100.0%**	**-0.32 [-0.82, 0.19]**

Heterogeneity: Tau² = 0.09; Chi² = 2.70, df = 1 (P = 0.10); I² = 63%
Test for overall effect: Z = 1.23 (P = 0.22)

Figure M: Infant Positive Affect at the Play Phase: Maternal PPA vs. Healthy Control Mothers

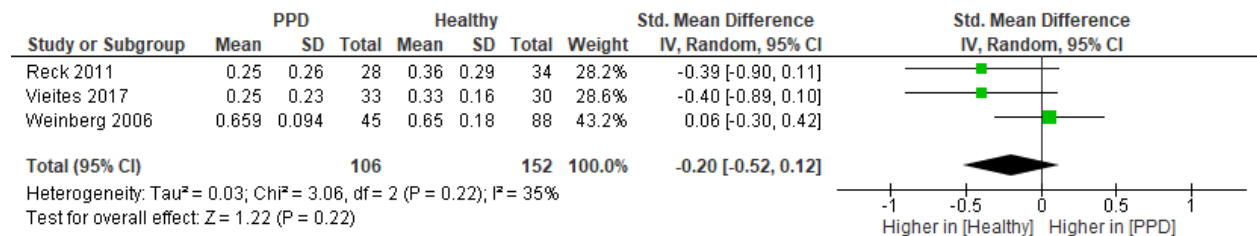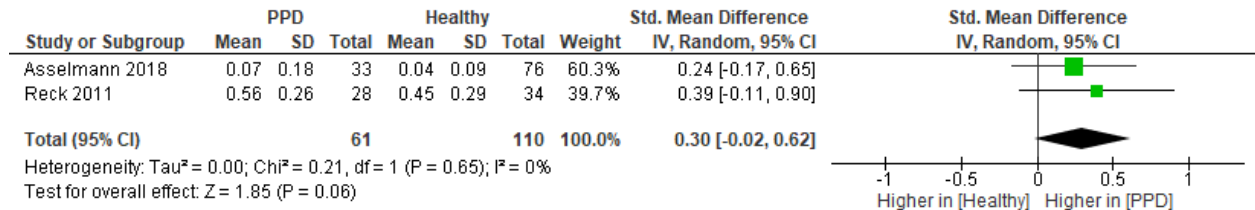**Figure N: Infant Positive Affect at the Still-Face Phase: Maternal PPA vs. Healthy Control Mothers**
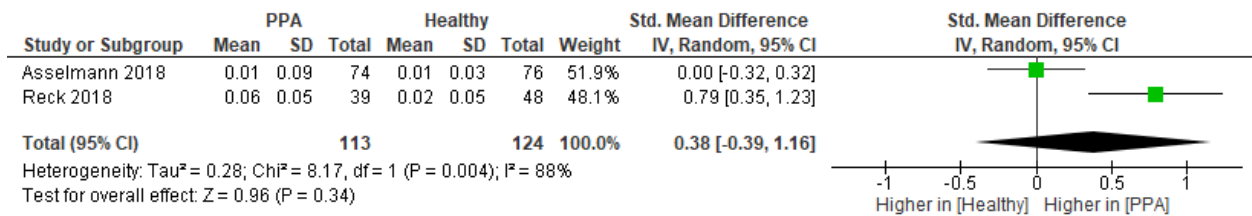
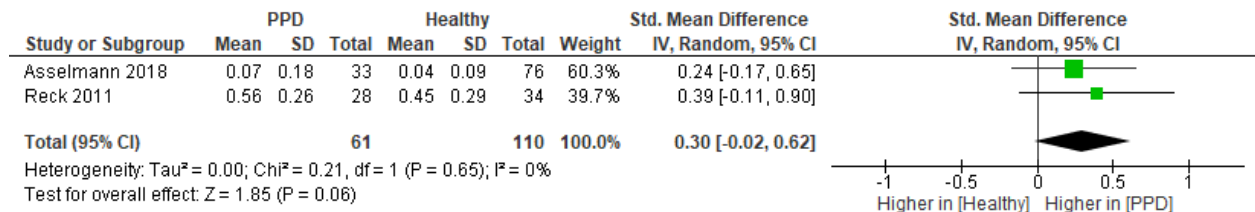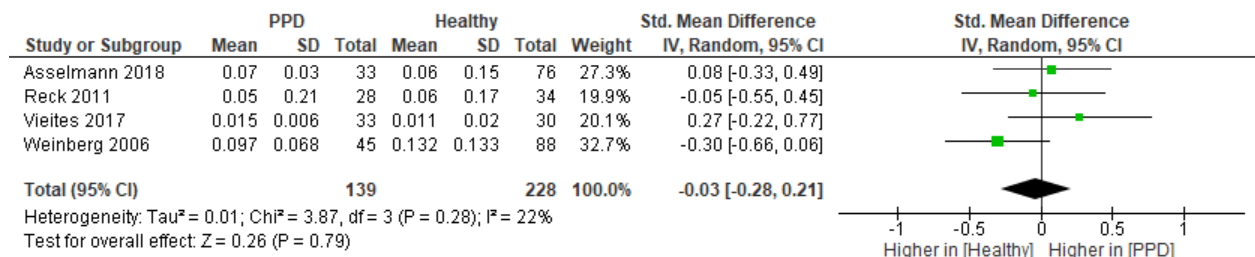**Figure O: Infant Positive Affect at the Reunion Phase: Maternal PPA vs. Healthy Control Mothers**
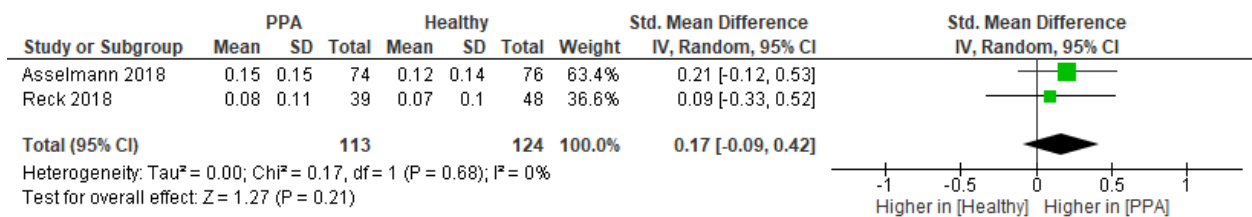
Figure P: Infant Object/Environment Engagement at the Play Phase: Maternal PPA vs. Healthy Control Mothers
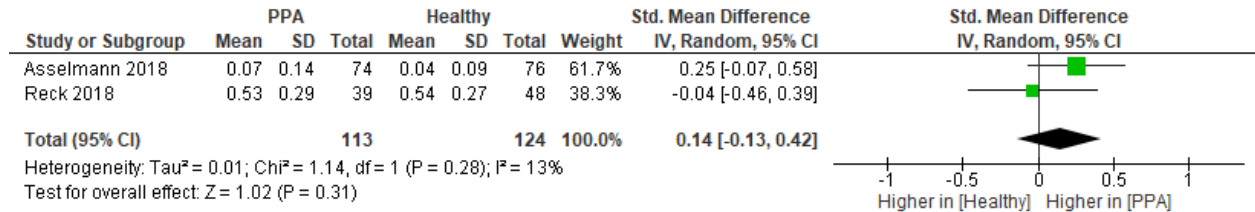
Figure Q: Infant Object/Environment Engagement at the Reunion Phase: Maternal PPA vs. Healthy Control Mothers
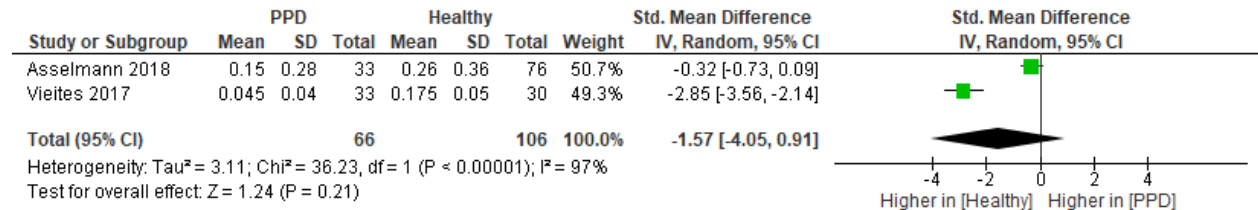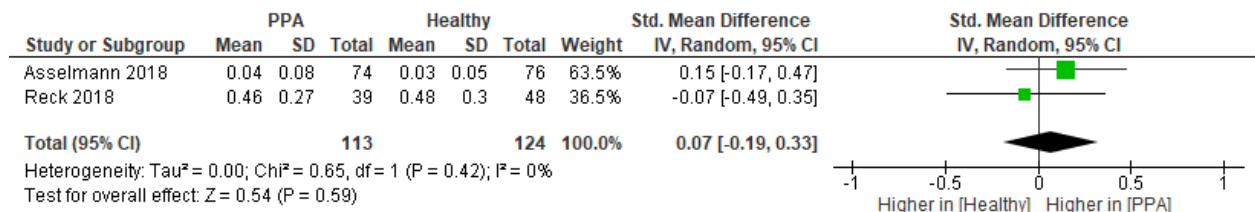

Figure R: Infant Negative Affect at the Play Phase: Maternal PPA vs. Healthy Control Mothers
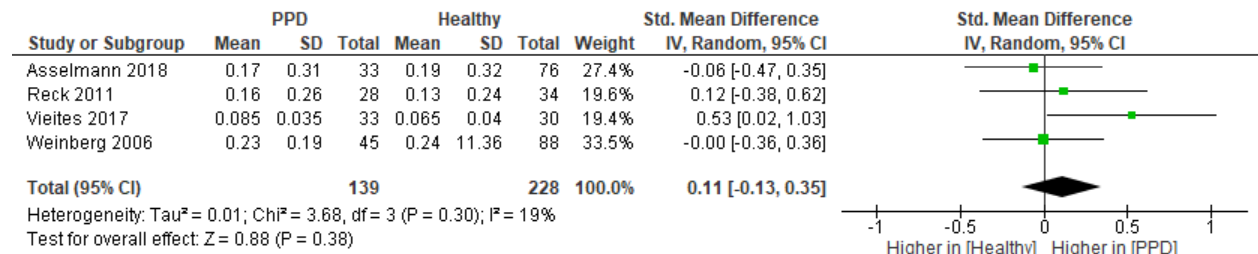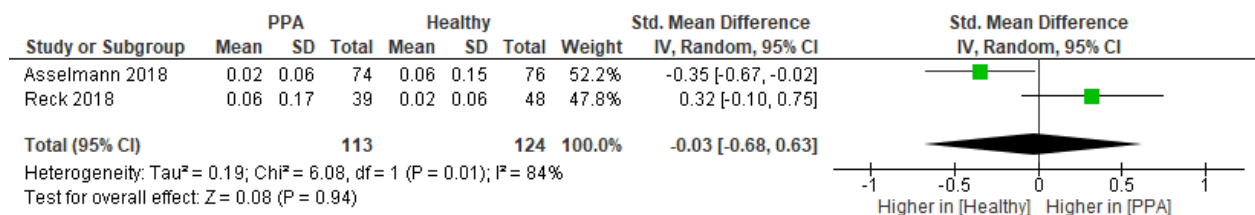
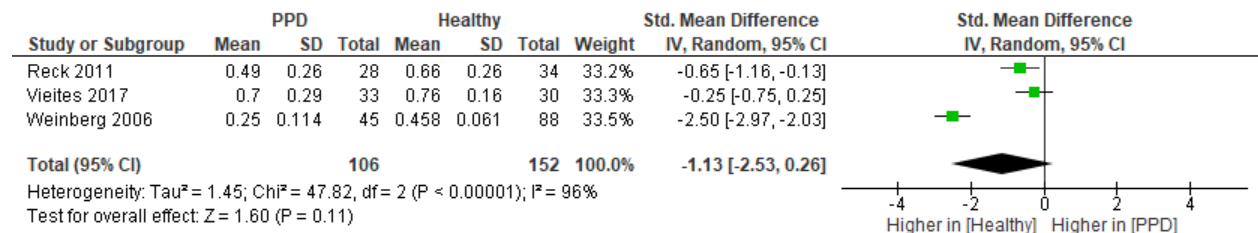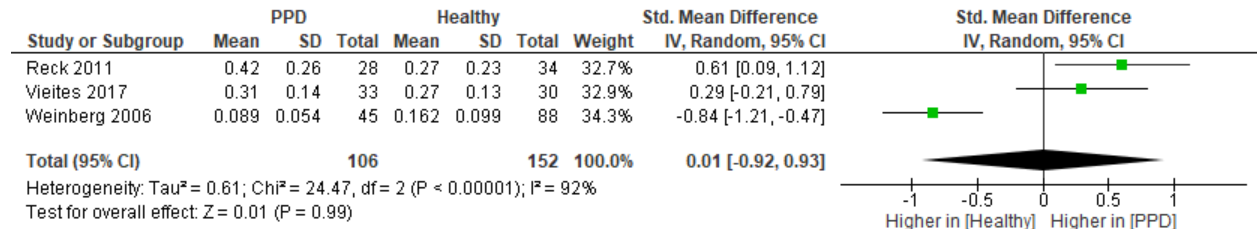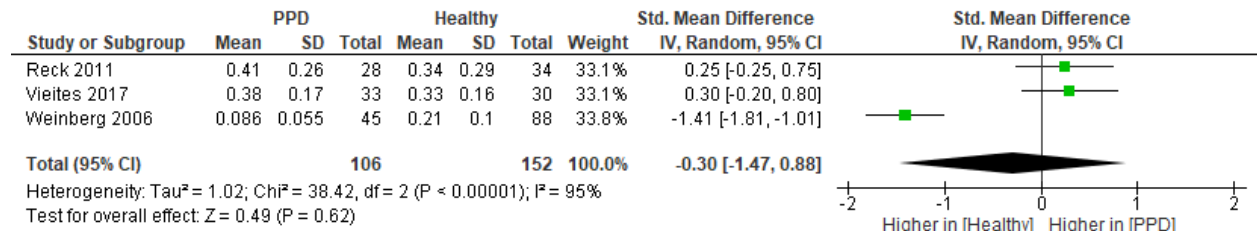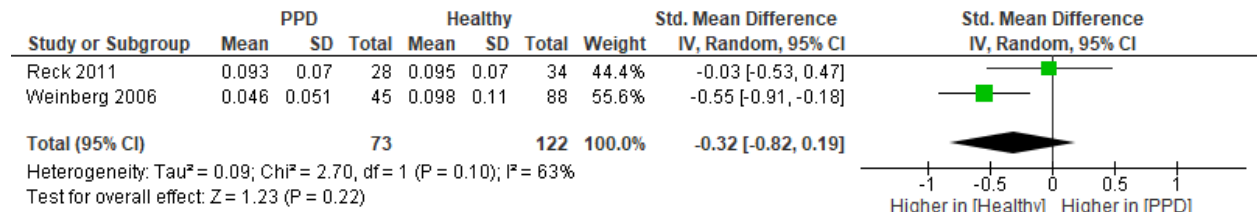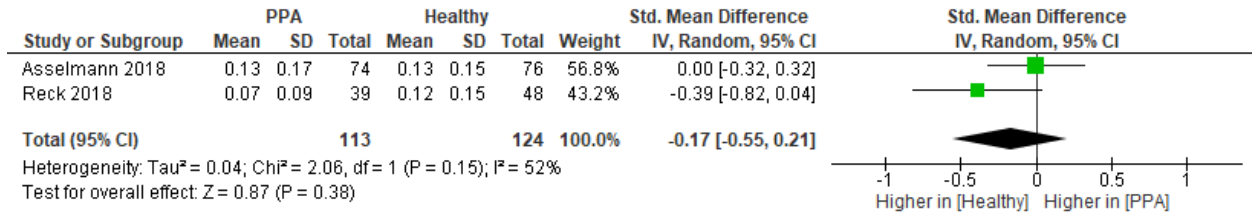**Figure S: Infant Negative Affect at the Still-Face Phase: Maternal PPA vs. Healthy Control Mothers**

	PPA			Healthy				Std. Mean Difference	Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random, 95% CI
Asselmann 2018	0.18	0.19	74	0.26	0.36	76	63.4%	-0.28 [-0.60, 0.05]	
Reck 2018	0.1	0.22	39	0.15	0.29	48	36.6%	-0.19 [-0.61, 0.23]	
Total (95% CI)			**113**			**124**	**100.0%**	**-0.24 [-0.50, 0.01]**	

Heterogeneity: Tau² = 0.00; Chi² = 0.10, df = 1 (P = 0.75); I² = 0%
Test for overall effect: Z = 1.87 (P = 0.06)

Higher in [Healthy]   Higher in [PPA]
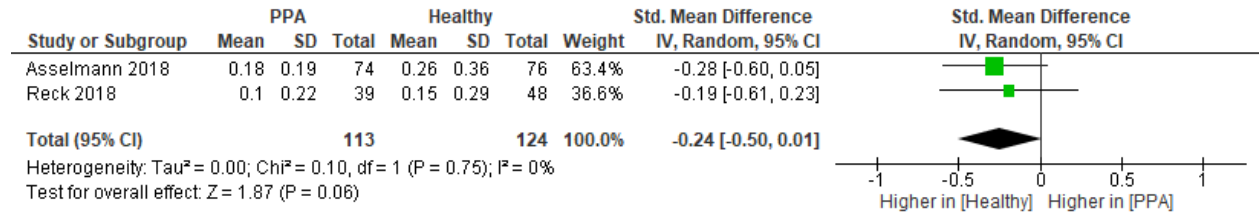
Figure T: Infant Negative Affect at the Reunion Phase: Maternal PPA vs. Healthy Control Mothers

	PPA			Healthy				Std. Mean Difference	Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random, 95% CI
Asselmann 2018	0.12	0.25	74	0.19	0.32	76	56.7%	-0.24 [-0.56, 0.08]	
Reck 2018	0.16	0.26	39	0.12	0.3	48	43.3%	0.14 [-0.28, 0.56]	
Total (95% CI)			**113**			**124**	**100.0%**	**-0.08 [-0.45, 0.29]**	

Heterogeneity: Tau² = 0.04; Chi² = 1.99, df = 1 (P = 0.16); I² = 50%
Test for overall effect: Z = 0.41 (P = 0.69)

Higher in [Healthy]   Higher in [PPA]
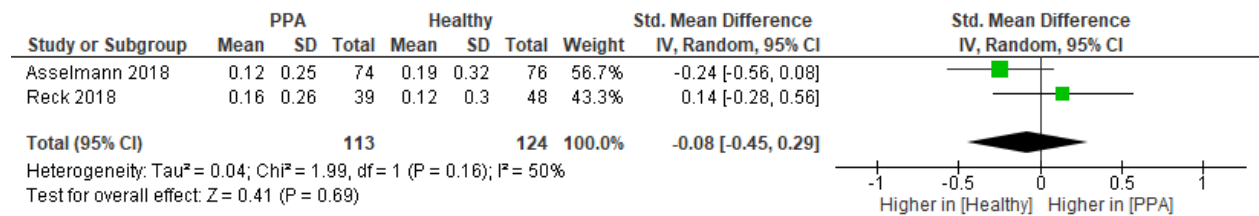
CHAPTER THREE: STUDY TWO

MATERNAL AND INFANT PERFORMANCE ON THE FACE-TO-FACE STILL-FACE

TASK FOLLOWING MATERNAL COGNITIVE BEHAVIORAL THERAPY FOR

POSTPARTUM DEPRESSION

Maternal and Infant Performance on the Face-to-Face Still-Face Task following Maternal Cognitive Behavioral Therapy for Postpartum Depression

Kwadjo O. Ntow[1*], H. BSc., John E. Krzeczkowski[2], H. BSc., Bahar Amani[2] MA., Calan D. Savoy[3], MSc., Louis A. Schmidt[4], Ph.D., Ryan J. Van Lieshout[3], MD., PhD.

[1]Global Health Graduate Program, McMaster University, Ontario, Canada

[2]Neuroscience Graduate Program, McMaster University, Ontario, Canada

[3]Department of Psychiatry and Behavioral Neurosciences, McMaster University, Ontario Canada

[4]Department of Psychology, Neuroscience & Behavior, McMaster University, Ontario Canada

Previous Presentation: N/A

Disclosures: All authors report no financial relationships with commercial interests

Location of Work: McMaster University, Hamilton, ON

*Please address correspondence to Kwadjo O. Ntow

Faculty of Health Sciences, Global Health Office

McMaster University

1280 Main St. West MDCL 3500

Tel: +1 905 525 9140, ext. 22350

Hamilton, Ontario, Canada L8S 4K1

Email: ntowko@mcmaster.ca

Abstract

Objective: This study examined the impact of treating postpartum depression (PPD) with cognitive-behavioral therapy (CBT) on mother and infant behavior on the face-to-face still-face (FFSF) task.

Methods: Data from 68 mothers and their infants, 35 women with PPD within 12 months of delivery, and 33 healthy controls matched on infant age, sex and familial socioeconomic status were examined. Women with PPD received nine weeks of group CBT and were examined at three timepoints, with healthy control dyads, on changes in mother-infant performance on the FFSF.

Results: A significant group x FFSF phase x visit interaction was observed for infant withdrawn behavior at the three months post-treatment ($p=0.006$). Infants of mothers with PPD displayed significantly less withdrawn behavior after treatment, normalizing to levels of control infants.

Conclusion: Three months after group CBT for PPD, infants' withdrawn behavior appears to normalize to levels seen in the infants of healthy controls.

Keywords: Mothers, infants, interaction, postpartum depression, cognitive behavioral therapy

Introduction

Postpartum depression (PPD) is one of the most common complications of childbirth, affecting up to 17% of all mothers (Gavin et al., 2005; Shorey et al., 2018). PPD not only has an adverse impact on mothers' thoughts, emotions, and functioning but can have significant detrimental effects on parenting (Field, 2010; Paulson et al., 2006) and the quality of dyadic interactions between mothers and their infants (Paris et al., 2009). Such alterations may contribute to the increased rates of emotional, behavioral and school problems seen in the offspring of mothers with PPD (Carter et al., 2001; O'Hara & McCabe, 2013; Rouse & Goodman, 2014).

Mother-infant interactions are coordinated toward a state of reciprocity of behavior and affect (Gianino & Tronick, 1988). According to the mutual regulation model (MRM), in healthy mother-infant dyads, mothers are sensitive and flexible during interactions and respond according to the communicative cues and actions of their infants (Gianino & Tronick, 1988; E. Z. Tronick & Weinberg, 1997). The ability to detect these signals and maintain flexibility in interactions leads to more positive and dynamic interaction patterns and healthy developmental trajectories (Mesman et al., 2009; E. Tronick & Reck, 2009). Conversely, when mothers have PPD, they are less responsive to their infants' behavior during interactions (Brummelte & Galea, 2016; E. Tronick & Reck, 2009). Over time, this can lead to more frequent miscoordination of emotions with fewer reparations (Gianino & Tronick, 1988). Under such conditions, infants are less able to regulate the negative state they experience and can develop more passive, detached and withdrawn behaviors (Kuczynski & Kochanska, 1990; E. Tronick & Reck, 2009).

65

Withdrawn reactions in infants are associated with unfavorable socio-emotional outcomes beyond infancy (Bernard-Bonnin, 2004; Milne et al., 2009) including poor interpersonal relationships, delays in language, academic difficulties and the development of psychopathology during childhood and adolescence (Guedeney et al., 2016; Rubin et al., 2009).

The face-to-face still-face (FFSF) task is a widely-used and validated method for assessing mother-infant mutual regulation and infant behavior (Mesman et al., 2009; E. Tronick et al., 1978). It consists of three sequential phases: play, still-face, and reunion phases. In the play phase, mothers interact with their infants as they usually would at home. During the still-face phase, mothers are instructed to keep a neutral (i.e., poker) face without touching or speaking to their infants. In the reunion phase, mothers can interact with their infants as they wish, utilizing the strategies they usually use to comfort their infant. During the play and reunion phases, mothers with PPD exhibit lower levels of positive engagement compared to non-depressed healthy mothers (Noe et al., 2015; E. Tronick & Reck, 2009). The infants of mothers with PPD are generally more withdrawn and disengaged during the entirety of the FFSF task compared to the infants of healthy mothers (Weinberg et al., 2006; Mesman et al., 2009). Infant withdrawn behavior during the FFSF task is thought to develop in response to the levels of negative mutual engagement that characterizes mother-infant interactions in the context of PPD.

Given the longstanding adverse effects of PPD on offspring, and the crucial role that mother-infant interactions play in their etiology, it is unclear how to improve maternal and offspring behavior most efficiently and effectively. While short-term psychotherapies focused on maternal symptoms like cognitive behavioral therapy (CBT) are evidence-based and cost-

effective (Butler et al., 2006; Huang et al., 2018; Sockol et al., 2011; Van Lieshout et al., 2017),

and preferred by some mothers over pharmacotherapy (Driessen & Hollon, 2010), whether

maternal treatment alone can alter mother and infant behavior is not well understood. To our

knowledge, only two other studies have investigated the effects of maternal PPD treatment on

infant behavior using the FFSF task. The first examined FFSF performance, but rather than

assessing FFSF phases separately, they generated an overall measure of infant emotionality, and

only examined this after treatment. However, they found no differences between the infants of

mothers treated with interpersonal psychotherapy (IPT) for PPD and those who were not

(Forman et al., 2007). The second was a small pilot study that administered the FFSF task before

and after an intervention that focused on the maternal response to infant behavior (Keys to

Caregiving program). This study contained 11 participants, lacked a control group, and examined

infants after only five weeks. They found an increase in infant interest and joyful behavior at the

play and reunion phases but not for sadness or anger after treatment (Jung et al., 2007). Since

PPD is common and presents a risk for mothers and their infants, it is important to explore

whether CBT treatment of maternal PPD alone can have favorable behavioral effects on the

mother-infant dyad. This could reduce the risks of depression, costs to families, and the burden

on healthcare systems and society in the short- and long-term.

Given the high prevalence of PPD and its long-term effects on mothers and infants, the

aim of this study was to determine if maternal PPD treatment (with group CBT) could alter

mother-infant performance on the FFSF task, both immediately after CBT and three months after

treatment. These changes were compared to infants born to healthy controls (i.e., non-depressed)

mothers matched on infant age and sex as well as familial socioeconomic status. Since CBT is an effective treatment for PPD, we hypothesized that mothers and infants in the PPD group would show improvements in behavioral outcomes over time and that these changes would normalize to healthy controls.

Methods

Participants

Mothers and their infants were recruited in Hamilton, Ontario, Canada, and neighboring regions from March 2016 to July 2019. The group consisting of mothers with PPD and their infants comprised 35 dyads. Women in this group were diagnosed with major depressive disorder (MDD) in the 12 months after the delivery of their infant. These women were patients at the Women Health Concerns Clinic at St. Joseph's Healthcare Hamilton. Diagnoses were made by mental health clinicians (social workers, psychologists, or nurses) using a structured clinical interview template and were reviewed and confirmed by perinatal psychiatrists. Mothers in the clinic diagnosed with MDD in the first postpartum year were offered a nine-week CBT intervention and then approached to participate in the study during the first CBT session. Mothers were ineligible for the study if they had comorbid bipolar disorder or schizophrenia spectrum disorder, were not fluent in English, or if their infants were older than 12 months.

Thirty-five non-depressed healthy control mothers and their infants (n=35) were matched with mothers with PPD on infant sex and age, as well as family socioeconomic status (SES) at baseline. These control dyads were included to determine if changes in mother-infant behavior

following PPD treatment improved to the levels of healthy dyads with PPD. This group was also recruited to attempt to isolate the effect of maternal PPD treatment on mother-infant dyads and try to rule out possible alternative explanations for any changes seen (e.g., familial socioeconomic disadvantage, infant age/neurodevelopmental stage, sex). Control mother-infant dyads were recruited from the Infant Database of the Department of Psychology Neuroscience and Behavior at McMaster University (Hamilton, Ontario, Canada). This database contains the names of mothers and their infants who were born healthy and full-term at the McMaster University Medical Centre or St. Joseph's Healthcare, Hamilton, Ontario. Control dyads were excluded from the study if mothers had MDD according to the Mini International Neuropsychiatric Interview (MINI), a validated structured diagnostic interview for DSM-defined psychiatric disorders (Sheehan et al., 1998). Women were also not eligible if they were not fluent in English, or if their infants were older than 12 months.

Study Design

The present work was part of a larger longitudinal examination of infants of women with PPD receiving CBT treatment and its impact on maternal and infant emotion regulation. Data were collected at three visits for both the PPD group and the control group. For the PPD group, visit 1 occurred following the first CBT session, visit 2 occurred immediately after CBT and was completed nine weeks later, and visit 3 occurred three months post-treatment (See Fig. 1). For the healthy control group, visit 1 was the baseline assessment, visit 2 occurred nine weeks after baseline (coinciding with the post-treatment visit in the PPD group), and visit 3 took place three months after visit 2. All women provided informed consent before participating, and the study

was approved by the Hamilton Integrated Research Ethics Board and conducted per the

Declaration of Helsinki.

Intervention: Women with PPD received a nine-week group CBT intervention (Van Lieshout et

al., 2017) administered by two trained therapists (psychiatrists, psychologists, psychiatric nurses

and social workers). Nine two-hour sessions took place weekly. The first half of each session

consisted of core CBT content, while the second half consisted of a psychoeducational

discussion topic co-led by patients and therapists. Maternal depressive symptoms were assessed

using the Edinburgh Postnatal Depression Scale (EPDS) (Cox et al., 1987) at each study visit to

determine the effects of CBT on PPD.

Figure 1: Study design
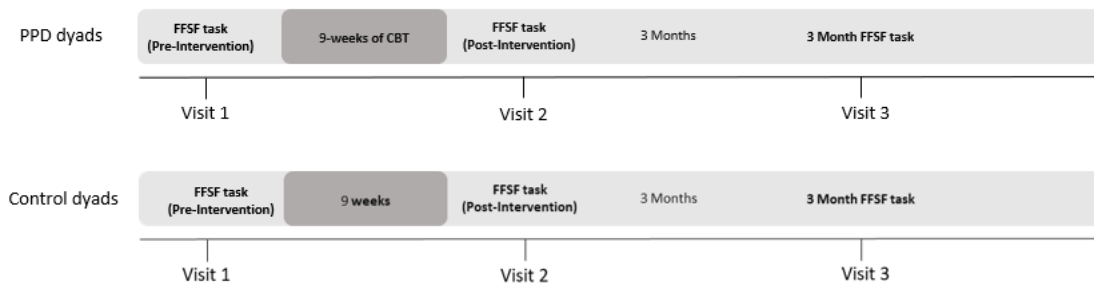
The face-to-face still-face task was administered at all three visits for both groups

FFSF Procedure

We administered the standard FFSF task, an extensively used procedure for measuring

mother and infant interactive behavior and regulation (Mesman et al., 2009; E. Tronick et al.,

1978). During the FFSF task, mothers were seated in a chair, and infants sat in a high-chair

facing their mother at eye-level. The FFSF procedure consists of three two-minute phases: play, still-face and reunion. During the play phase, mothers are instructed to interact with their infants as they usually would at home without the use of toys or a pacifier. In the still-face phase, mothers were told to keep a 'poker' face, which involved looking at their infant without any facial expressions, touching, or speaking. For the reunion phase, mothers were instructed to resume playing with their infants as they did in the play phase. The transition from one phase to another was marked by a visual signal provided by a female research assistant out of the infant's field of view. Two cameras were placed at different angles to ensure that all facial expressions, behaviors and vocalizations of participants were captured clearly. The FFSF task was administered for all three visits at the Child Emotion Laboratory at McMaster University.

Infant and mother performance and interactive behavior were coded using the Infant Caregiver Engagement Phases (ICEP) system, a widely-used and reliable means of assessing mother and infant behaviors during on the FFSF task (Reck, Noe, and Cenciotti, 2008; Tronick et al., 2005; Weinberg and Tronick, 1998). The ICEP contains a set of mutually exclusive mother and infant codes and combines facial expressions, the direction of gaze, vocalizations and behavior. The proportion of ICEP codes per phase was calculated for analyses by dividing the total duration of behavior (in seconds) by the entire length of the phase and ranged between 0 and 1 (multiplied by 100% for descriptive purposes).

Possible ICEP codes for infant behavior include withdrawn, protest, social positive engagement, social monitor and object/environment engagement. Withdrawn behavior is characterized by sad facial expressions, whimpering/fussy vocalizations, bent posture and

disengagement from the mother. Protest is scored when emotions of anger, crying and fussiness are present. Object/environment engagement occurs when the infant is actively looking at inanimate objects and surroundings, including the infant's hand, seat, belly, wall posters, cameras and the floor. This behavior during the FFSF task is suggestive of self-soothing and regulation. Social monitoring describes the infant's focused attention toward their mother's face, with a neutral expression. Social positive engagement is identified by infant displays of joyful and playful facial expressions, including laughing, smiling, or babbling with occasional cooing towards the mother. Overall, infants of healthy control mothers show more positive engagement and less negative behavior compared to infants of mothers with PPD (Mesman et al., 2009; E. Tronick & Reck, 2009).

Potential maternal ICEP codes are withdrawn, hostile/intrusive, non-infant-focused engagement, social monitor with no/neutral vocalizations, social monitor with positive vocalizations and social positive engagement. Withdrawn behavior is characterized by minimal involvement and unresponsiveness toward the infant. Hostile/intrusive behavior includes aggression, irritation and anger towards the infant. Non-infant focused engagement involves activities that are not focused on the infant. Social monitor with no or neutral vocalizations is characterized by a focus on the infant's face with a neutral facial expression. Social monitor with positive vocalizations is when the mother is focused on the infant's face with occasional smiles and positive vocalizations. Exaggerated positive engagement occurs when mothers display overstated levels of laughter and play. Social positive engagement is coded when the mother shows positive affect, including smiles, laughter and play faces. In general, healthy control

mothers are more likely to display more social positive engagement and less negative

engagement with their infants on the FFSF compared to mothers with PPD (E. Tronick & Reck,

2009).

The FFSF procedure was videotaped, and mother and infant behaviors were coded as

continuous outcomes, micro-analytically (second-by-second), using the Behavioral Observation

Research Interactive Software (BORIS) (Friard & Gamba, 2016). Two trained independent raters

coded all FFSF digital recordings and were blind to study hypotheses, groups and visits. To

assess inter-rater reliability, 25% of all videos were randomly selected and re-coded by a trained

Ph.D. student to calculate Cohen's κ (Cohen, 1960). Mean κ values were 0.81 for infant ICEP

outcomes and 0.82 for mothers. These values are classified as substantial (McHugh, 2012), and

consistent with other FFSF studies (Reck. et al., 2018; Noe et al., 2015; Sravish et al., 2013).

Statistical analyses

A 2 x 3 x 3 repeated-measures analysis of variance (ANOVA) was conducted to test the

effects of group (treated PPD group, control), FFSF phase (play, still-face, reunion) and study

visit (visit 1, visit 2, visit 3) on infant outcomes. A 2 x 2 x 3 repeated-measures ANOVA was

also conducted for maternal outcomes but did not include still-face phase data (because all

mothers were instructed to keep a straight face then). The between-subjects factor was group,

and the two within-subject factors were the FFSF phase and visit. Mauchly's sphericity test was

conducted to assess sphericity, and Huynh-Feldt corrections were used on degrees of freedom if

this assumption was violated. Cohen's partial eta-squared (η^2) was applied to estimate the effect size in our ANOVA models (Cohen, 2013; Daly & Cohen, 1978).

In keeping with previous studies (Corinna Reck, Tietz, Müller, et al., 2018; Vieites & Reeb-Sutherland, 2017), maternal withdrawn, hostile/intrusive engagement, non-infant focused and exaggerated positive engagement occurred <1% of the time and were therefore excluded from analyses. A conservative approach was taken for missing data in that listwise deletion was employed to remove participants if they failed to complete the FFSF task at all three phases within a visit or all three visits. Little's Missing Completely at Random (MCAR) test (Little, 1988) was conducted to ensure similarity between participants who had missing FFSF data versus those with complete data. This procedure was done to confirm the validity of listwise deletions and has been used in other studies (Muller et al., 2015, 2016; Nazzari et al., 2019; Reck et al., 2018a). All statistical analyses were completed using IBM® SPSS Statistics 23®, and statistical significance was two-tailed and set at α=0.05. α-errors of our ANOVA analyses for multiple testing were not adjusted since this study is exploratory in nature (Jebb et al., 2017).

Results

Sample Characteristics

The sociodemographic characteristics of participants in the study are summarized in Table 1. Infant age at study baseline was (mean [SD]) 5.6 months [2.6], and 43% of the infants were male. Mothers were 32.7 years [4.3] of age on average. Infant birth weight was 3350 grams [480], and all infants were born full-term. Average household income was CAD 85,000 [29,621],

and 94% of women were married or living common-law. There were no differences between case and control dyads on any of our matching criteria (age, sex and family SES). Of the women with PPD, 14 (27%) were diagnosed with also a comorbid psychiatric condition (most commonly generalized anxiety disorder), and 18 (35%) were taking psychiatric medications during the study [5 (14%) women increased the dose of their medication during CBT treatment]. Of the 51 women with PPD recruited, 35 (69%) completed all three study visits, and 33 (72%) of the 46 control dyads recruited completed all three visits. For both PPD and control groups, there were no significant differences between dyads that completed all three study visits versus those that did not (see Table 2). Overall, 15 participant videos were excluded from analyses (one due to a broken video file, six because of infants falling asleep and eight due to excessive infant protesting, leading to the abrupt stoppage of the task). Of these, nine were excluded from the PPD group (eight at visit 1 and one at visit 3) while eight were excluded for the control group (two at visit 1, four at visit 2 and two at visit 3). The MCAR-test was not significant (χ^2= 128.67, df = 179, $p > 0.99$), suggesting that listwise deletion was an appropriate method of managing missing data, and our analyzed sample is reflective of the larger sample.

In women with PPD, a clinically significant decrease in depressive symptoms was observed immediately following treatment (EPDSΔ= 4.1 points, p=0.001, d= 0.75), and effects were maintained at visit 3 (EPDSΔ visit 1 to visit 3= 4.0 points, p= 0.03, d= 0.74).

Table 1: Summary of Sample Characteristics and Test of Comparability

	PPD group (n=35)	Control group (n=33)	*P*
Infant age at enrollment, M (SD) months	5.7 (2.7)	5.5 (2.5)	0.78
Infant sex, No. (%) male	20 (57.1)	19 (57.6)	0.97
Total household income (CAD) M (SD)			
<49,999	6 (17.1)	4 (12.1)	0.81
50,000-79,999	9 (25.7)	8 (24.2)	
>80,000	20 (57.1)	21 (63.6)	
EPDS score M (SD)			
Visit 1	14.4 (5.3)	4.9 (3.7)	<0.001
Visit 2	10.8 (5.1)	4.7 (4.3)	<0.001
Visit 3	10.2 (6.3)	5.1 (4.1)	0.004
Maternal age at enrollment, M (SD) years	32.7 (3.9)	32.7 (4.7)	0.97
Parity, No. (%)			
Primiparous	18 (51.4)	17 (51.5)	0.99
Multiparous	17 (48.6)	16 (48.5)	
Marital status, No. (%)			
Single	2 (5.7)	2 (6.1)	0.76
Separated	9 (25.7)	6 (18.2)	
Common-law	24 (86.6)	25 (75.8)	
Married			
Education, No. (%)	3 (8.6)	2 (6.1)	
High school or less	11 (31.4)	10 (30.3)	0.91
College or certificate program	21 (60.0)	21 (63.6)	
University or higher			
Birthweight M (SD), grams	3314.2 (463.8)	3388.6 (500.3)	0.53
Gestational age at delivery M (SD) weeks	39.5 (2.2)	39.2 (1.1)	0.43

M: Mean
SD: Standard Deviation
CAD: Canadian Dollars
EPDS: Edinburgh Postnatal Depression Scale

Infant Behavior on the FFSF

Infant Withdrawn Behavior: Significant main effects of FFSF phase ($F_{2, 52} = 8.53$, *p*= 0.001, $\eta^2 = 0.24$) and visit ($F_{1.79, 48.1} = 9.21$, *p*= 0.001, $\eta^2 = 0.25$) were observed. More specifically, in keeping with previous research, there was an increase in withdrawn infant behavior from play to still-face, and a significant decrease from still-face to reunion phases. There was also a decrease in withdrawn behavior from visit 1 to visit and visit 2 to visit 3 across

all three phases. These were qualified by the interaction term group x phase x visit, which was significant ($F_{3.1, 84.1} = 13.6$, $p= 0.006$, $\eta^2= 0.14$) (See Fig. 2 & Table 2).

Post-hoc pairwise comparison tests revealed that in the PPD group, there was a decrease in infant withdrawn behavior across visits 1 to 3, and a statistically significant decline in withdrawn behavior in the play phase from visit 2 to visit 3 ($p= 0.02$). There was also a statistically significant decrease from visit 1 to visit 3 in the still-face phase ($p= 0.001$). Additionally, we observed a decrease in withdrawn behavior during still-face from visit 1 to visit 2 ($p= 0.04$). These findings suggest that infants in the PPD group show lower levels of withdrawn behavior immediately after treatment and that these improve further through to three-months post-treatment.

By visit 3, infants in the PPD group did not differ from infants in the control group at any of the three FFSF phases, suggesting that their behavior normalized to healthy control levels with maternal treatment with CBT, but that this did not completely normalize until visit 3.

Infant Protest: There were main effects for phase ($F_{2, 54} = 25.7$, $p< 0.000$, $\eta^2 = 0.49$), but not for visit ($F_{2, 54} = 7.72$, $p= 0.79$), and there was a significant increase from play to still-face and play to reunion in both groups. The group x phase x visit interaction term was not significant ($F_{4, 108} = 0.24$, $p= 0.92$). This means that there were no differences for infant protest from visit 1 to visit 2 to visit 3 for infants either groups.

Infant Object/Environment Engagement: There was no main effect for phase ($F_{2, 54} = 2.21$, $p= 0.12$) but there was one for visit ($F_{2, 54} = 7.73$, $p= 0.001$, $\eta^2= 0.22$). We discovered that

there was a significant increase in object/environment engagement from visit 1 to visit 2 and visit 1 to visit 3 without considering groups or phases. The group x phase x visit interaction term was not significant ($F_{4,\,108} = 1.14$, $p = 0.37$). Thus, there were no group differences in object/environment engagement over time.

Infant Social Monitor: There were no main effects for phase ($F_{1.5,\,40.2} = 2.30$, $p = 0.13$) and visit ($F_{1.6,\,43.7} = 0.84$, $p = 0.42$). The group x phase x visit interaction term was also not statistically significant ($F_{1.9,\,50.8} = 0.51$, $p = 0.59$). This result shows that there were no changes for infant protest behavior from visit 1 to visit 3 for either group.

Infant Social Positive Engagement: There were main effects for phase ($F_{2,\,54} = 19.0$, $p < 0.000$, $\eta^2 = 0.41$) though there was not one for visit ($F_{2,\,54} = 1.52$, $p = 0.23$). We observed that there was a significant decrease from play to still-face and play to reunion in both groups at all visits. There was also a significant increase from still-face to reunion for both groups. The group x phase x visit interaction term was not significant ($F_{4,\,108} = 2.04$, $p = 0.09$).

Table 2: Infant Outcomes During the Face-to-Face Still-Face Task

	Pre-treatment M (SE)		Immediately post-treatment M (SE)		Three months post-treatment M (SE)	
	PPD	Controls	PPD	Controls	PPD	Controls
Play Phase						
Withdrawn[*, a, b]	10.1 (8.7)	30.1 (8.3)	27.5 (6.6)	6.5 (6.3)	6.0 (3.6)	7.6 (3.4)
Protest [a]	22.2 (8.8)	16.8 (8.4)	11.5 (4.3)	13.0 (4.1)	15.8 (5.4)	4.4 (5.1)
Object/Environment Engagement [b]	8.2 (6.9)	19.7 (6.7)	21.1 (8.0)	28.9 (7.6)	27.3 (9.1)	26.1 (8.7)
Social Monitor	37.6 (9.1)	21.1 (8.7)	30.0 (8.1)	27.0 (7.8)	31.3 (7.3)	26.6 (6.9)
Social Positive Engagement [a]	16.1 (8.3)	11.2 (7.9)	8.2 (6.3)	23.5 (6.0)	17.3 (7.7)	33.8 (7.3)

Still-Face Phase

Withdrawn[*, a, b]	47.1 (11.8)	32.7 (11.2)	27.2 (6.7)	10.7 (6.3)	4.3 (3.2)	2.6 (3.0)
Protest [a]	25.2 (10.6)	33.5 (10.1)	45.9 (10.8)	42.1 (10.3)	42.5 (11.3)	29.0 (10.8)
Object/Environment Engagement [b]	5.5 (6.3)	10.3 (6.0)	17.2 (9.0)	22.7 (8.6)	40.7 (10.8)	53.3 (10.3)
Social Monitor	19.1 (14.6)	20.1 (23.5)	7.4 (7.5)	19.2 (7.2)	8.7 (3.6)	10.7 (3.5)
Social Positive Engagement [a]	0.3 (1.2)	2.8 (1.2)	0.2 (0.4)	0.7 (0.4)	1.2 (2.1)	2.7 (2.0)

Reunion Phase

Withdrawn[*, a, b]	15.1 (7.3)	16.3 (6.9)	20.6 (4.6)	5.7 (4.4)	2.5 (1.0)	0.0 (1.0)
Protest [a]	42.0 (12.2)	38.6 (11.6)	24.2 (9.3)	33.9 (8.8)	35.0 (10.4)	40.4 (9.9)
Object/Environment Engagement [b]	1.5 (4.3)	7.1 (4.1)	20.6 (9.7)	21.6 (9.3)	19.3 (9.2)	38.8 (8.8)
Social Monitor	27.1 (8.9)	24.2 (8.5)	28.7 (9.2)	25.1 (8.8)	19.9 (6.6)	9.2 (6.3)
Social Positive Engagement [a]	13.7 (7.3)	10.2 (7.0)	5.0 (4.0)	8.9 (3.8)	19.8 (7.5)	9.5 (7.2)

Percentage of time for infants' behavioral outcomes in each phase, and at each visit
M: Mean
SE: Standard Error
[*] Statistically significant group x phase x visit interaction effect
[a] Statistically significant phase main effect
[b] Statistically significant visit main effect

Figure 2: Group x Phase x Visit Interaction of Infant Withdrawn Behavior
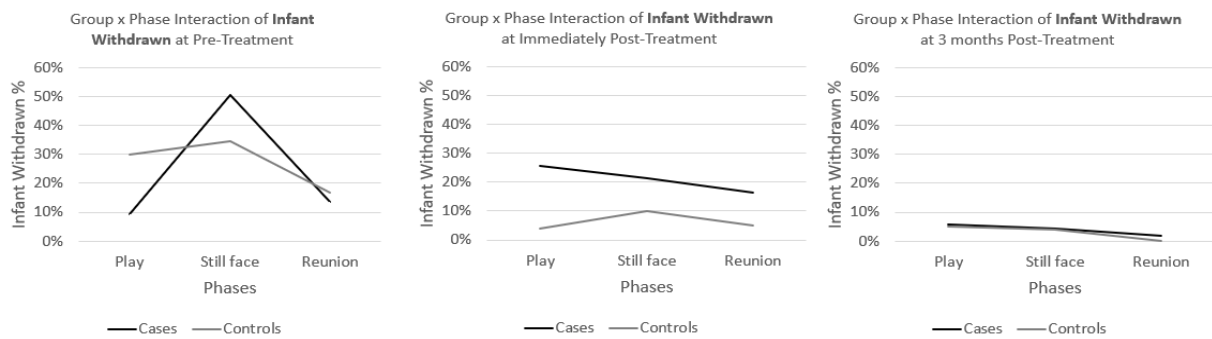
This represents the mean proportions of infant withdrawn behavior in each phase, between cases and control at three assessment timepoints (visits)
Group x Phase x Visit interaction significant at $p < 0.01$.

Maternal Behavior on the FFSF

There were no main effects for phase (p= 0.28-0.89) or visit (p= 0.29-0.44) for social positive engagement, social monitor with positive vocalizations, or social monitor with no/neutral vocalizations. The group x phase x visit interaction terms were also not significant (p= 0.16-0.30) (See Table 4).

Discussion

This study examined whether the treatment of maternal PPD with CBT leads to changes in infant and maternal behavior on the FFSF task. The results of this work suggest that the infants of depressed mothers show decreases in withdrawn behavior in response to maternal treatment and normalize to the levels of infants of non-depressed mothers three months after the completion of maternal treatment. More specifically, during the still-face phase of the FFSF task, the infants of healthy control mothers had lower levels of withdrawn behavior at baseline and nine weeks later, relative to the PPD group. However, three months after treatment was completed, levels of withdrawn behavior in the PPD group normalized to levels in control infants across all three phases of the FFSF task.

Infant withdrawn behavior in the FFSF task is the most common type of response noted in studies of mothers with PPD using the FFSF task (Oppenheimer et al., 2013; E. Tronick & Reck, 2009; E. Z. Tronick & Weinberg, 1997). Studies suggest that the infants of mothers with depression are more disengaged and withdrawn because they have become familiar with their mothers' less responsive behavior at home (Dawson et al., 2000; Field et al., 2007; Mesman et

al., 2009). Maternal PPD is associated with less predictable behavior on the part of mothers, which can lead infants to struggle with focusing their attention on mothers during mutual interactions (Nadel et al., 2005; Skotheim et al., 2013). However, it is unclear why maternal treatment with group CBT leads to changes in infant withdrawn behavior. Perhaps improvements in depressive symptoms play a role, or the emergence of more consistent and predictable day-to-day interactions occurring with maternal recovery. In this study, withdrawn behavior in the infants of mothers with PPD did not normalize to the levels of the infants of matched healthy control mothers until three months after CBT treatment. This suggests that the time course for infant recovery is longer than for improvements in maternal depressive symptoms (which occurred by nine weeks). Perhaps these infant changes only manifest after more predictable social interactions accumulate over time in the dyad.

However, changes in infant protest, object/environment engagement, social monitor and social positive engagement were not observed after maternal treatment for PPD. The reasons for this are unclear, and so it is uncertain if this is because of limitations in the FFSF in differentiating between infants of mothers with PPD versus infants of non-depressed mothers on these subscales. In previous work, infant protest (Peláez-Nogueras et al., 1996; Stanley et al., 2004), object/environment engagement (Asselmann et al., 2018; Lotzin et al., 2015), social monitor (Stanley et al., 2004; Vieites & Reeb-Sutherland, 2017) and social positive engagement (Moore et al., 2001; Stanley et al., 2004) has been found to occur at similar levels in the infants of mothers with PPD and those born to non-depressed mothers across all phases of the FFSF. The lack of change in these infant behaviors after maternal PPD treatment could relate to

limitations in the ability of the FFSF task to detect changes over time in response to treatment. It is also possible that the relatively short duration of the FFSF task is not sufficient to challenge infants and elicit the changes needed to detect differences occurring with treatment. In this study, the still-face phase of the FFSF was two minutes long. However, other studies using a three-minute phase have presented more extreme infant responses to the task (Mayes & Carter, 1990; E. Tronick et al., 1978), suggesting that with a more extended FFSF task, the differences between the two infant groups would have been observed. It is also important to acknowledge that differences were not seen because maternal PPD treatment fails to lead to changes in these specific infant behaviors, or that therapies directed at the mother-infant dyad or required to produce improvements in these outcomes.

We should note that no significant changes were observed in maternal FFSF outcomes with CBT treatment. It is unknown if this is due to limitations in the task itself in detecting change occurring in response to maternal treatment, or if the fact that the FFSF was conducted in a less natural setting (the laboratory). Our experimental setup may have restricted the more naturalistic maternal behaviors that may have been seen in their homes or other 'real-life' settings (Stanley et al., 2004; E. Tronick & Reck, 2009). The brevity of the mother-infant interactions recorded (two minutes per two phases) may have also contributed as mothers may not have been able to manage their behaviors very carefully during such a short period. Mother-infant interaction patterns are intricate (Fadda & Lucarelli, 2017; Leclère et al., 2014) and may require more time per FFSF phase to emerge, or a less structured task is required to detect these changes. Finally,

maternal treatment alone (vs. dyadic treatments) may be insufficient to change maternal behavior in this dyadic task.

This study has some limitations which should be considered. First, our sample size was relatively small and consisted mainly of Caucasian women who were married or in common-law partnerships. Also, the PPD group comprised of referred, clinically depressed mothers diagnosed by healthcare professionals. Together, these factors could affect our findings and the generalizability of our results. Second, the fact that a portion of mothers in the PPD group also had comorbid postpartum anxiety (PPA) could have limited the level of improvements in mother and infant FFSF behavioral outcomes after treatment. Studies have indicated that infants of mothers with PPD behave differently and have different outcomes compared to infants of mothers with comorbid PPD and PPA on the FFSF task (Asselmann et al., 2018; Feldman et al., 2009). Hence, the presence of comorbid PPA in the PPD group may have influenced the level of change that occurred since some mothers had more complex mental health problems at baseline. Third, brief group CBT (nine weeks) may not be enough to produce significant changes in mother and infant behavior on the FFSF task, and perhaps a more extended treatment course was needed. Also, possibly more considerable FFSF behavioral changes could have been observed with a mother-infant directed psychotherapy, in comparison to maternal CBT treatment only. Finally, the FFSF procedure may not be sensitive to capturing specific behavioral outcomes, especially maternal engagement, because the task is prone to social desirability bias as mothers are aware of being videotaped (Lovejoy et al., 2000; Reck et al., 2018b; Vieites and Reeb-Sutherland, 2017).

Postpartum depression has significant adverse effects on mothers and their infants. Still, this study suggests that a brief, cost-effective, and widely available non-pharmacological treatment for PPD can lead to adaptive behavioral changes in infants that have positive longer-term effects on their development and the mental health of these offspring and their mothers. Future studies should consider examining more extensive and more diverse community samples and investigate outcomes over the longer-term to monitor which behaviors change and when. They should also attempt to determine whether therapies directed at the mother-infant dyad have differential effects on mothers and their infants. Ultimately, understanding how maternal treatment for PPD affects both mothers and their infants can help develop therapies that optimize outcomes for the entire family.

Authorship

K.O. Ntow was involved in research question formulation, data acquisition, and preparation of the initial manuscript draft. J.E. Krzeczkowski and R.J. Van Lieshout developed the study design and study concept. C. D. Savoy oversaw the data plan and statistical analyses. B. Amani and L.A. Schmidt contributed to the conceptualization and interpretation of results. All authors critically reviewed, edited, and approved of the manuscript for publication submission.

Acknowledgments

We would like to acknowledge Ms. Merwa Amer, Zoe Tsai, and all the women who participated in the study, along with their infants.

References

Asselmann, E., Venz, J., Wittchen, H.-U., & Martini, J. (2018). Maternal anxiety and depressive

disorders prior to, during and after pregnancy and infant interaction behaviors during the

Face-to-Face Still Face Task at 4 months postpartum: A prospective-longitudinal study.

Early Human Development, *122*, 45–53.

https://doi.org/https://dx.doi.org/10.1016/j.earlhumdev.2018.05.007

Bernard-Bonnin, A.-C. (2004). Maternal depression and child development. *Paediatrics & Child

Health*, *9*(8), 575. https://doi.org/10.1093/pch/9.8.575

Brummelte, S., & Galea, L. A. M. (2016). Postpartum depression: Etiology, treatment and

consequences for maternal care. *Hormones and Behavior*.

https://doi.org/10.1016/j.yhbeh.2015.08.008

Butler, A. C., Chapman, J. E., Forman, E. M., & Beck, A. T. (2006). The empirical status of

cognitive-behavioral therapy: A review of meta-analyses. *Clinical Psychology Review*, *26*,

17–31. https://doi.org/10.1016/j.cpr.2005.07.003

C., R., A., T., M., M., & K., S. (2018). The impact of maternal anxiety disorder on mother-infant

interaction in the postpartum period. *PLoS ONE*, *13*(5), e0194763.

https://doi.org/http://dx.doi.org/10.1371/journal.pone.0194763

Carter, A. S., Garrity-Rokous, F. E., Chazan-Cohen, R., Little, C., & Briggs-Gowan, M. J.

(2001). Maternal depression and comorbidity: Predicting early parenting, attachment

security, and toddler social-emotional problems and competencies. *Journal of the American Academy of Child and Adolescent Psychiatry*, *40*(1), 18–26. https://doi.org/10.1097/00004583-200101000-00012

Cohen, J. (1960). A coefficient of agreement for nominal scales. *Educational and Psychological Measurement*, *20*(1), 37–46.

Cohen, J. (2013). Statistical Power Analysis for the Behavioral Sciences. In *Statistical Power Analysis for the Behavioral Sciences*. https://doi.org/10.4324/9780203771587

Cox, J. L., Holden, J. M., & Sagovsky, R. (1987). Detection of Postnatal Depression: Development of the 10-item Edinburgh Postnatal Depression scale. *British Journal of Psychiatry*, *150*(JUNE), 782–786. https://doi.org/10.1192/bjp.150.6.782

Daly, J. C., & Cohen, J. (1978). Statistical Power Analysis for the Behavioral Sciences, Revised Edition. *Journal of the American Statistical Association*. https://doi.org/10.2307/2286629

Dawson, G., Ashman, S. B., & Carver, L. J. (2000). The role of early experience in shaping behavioral and brain development and its implications for social policy. *Development and Psychopathology*. https://doi.org/10.1017/S0954579400004089

Driessen, E., & Hollon, S. D. (2010). Cognitive behavioral therapy for mood disorders: Efficacy, moderators and mediators. In *Psychiatric Clinics of North America*. https://doi.org/10.1016/j.psc.2010.04.005

Fadda, R., & Lucarelli, L. (2017). Mother-infant and extra-dyadic interactions with a new social partner: Developmental trajectories of early social abilities during play. *Frontiers in Psychology*. https://doi.org/10.3389/fpsyg.2017.00436

Feldman, R., Granat, A., Pariente, C., Kanety, H., Kuint, J., & Gilboa-Schechtman, E. (2009). Maternal Depression and Anxiety Across the Postpartum Year and Infant Social Engagement, Fear Regulation, and Stress Reactivity. *Journal of the American Academy of Child and Adolescent Psychiatry*. https://doi.org/10.1097/CHI.0b013e3181b21651

Field, T. (2010). Postpartum depression effects on early interactions, parenting, and safety practices: A review. In *Infant Behavior and Development*. https://doi.org/10.1016/j.infbeh.2009.10.005

Field, T., Hernandez-Reif, M., Diego, M., Feijo, L., Vera, Y., Gil, K., & Sanders, C. (2007). Still-face and separation effects on depressed mother-infant interactions. *Infant Mental Health Journal*. https://doi.org/10.1002/imhj.20138

Forman, D. R., O'Hara, M. W., Stuart, S., Gorman, L. L., Larsen, K. E., & Coy, K. C. (2007). Effective treatment for postpartum depression is not sufficient to improve the developing mother-child relationship. *Development and Psychopathology*. https://doi.org/10.1017/S0954579407070289

Friard, O., & Gamba, M. (2016). BORIS: a free, versatile open-source event-logging software for video/audio coding and live observations. *Methods in Ecology and Evolution*, *7*(11),

1325–1330. https://doi.org/10.1111/2041-210X.12584

Gavin, N. I., Gaynes, B. N., Lohr, K. N., Meltzer-Brody, S., Gartlehner, G., & Swinson, T. (2005). Perinatal Depression: A Systematic Review of Prevalence and Incidence. *Obstetrics & Gynecology*, *106*(5), 1071–1083. https://doi.org/10.1097/01.AOG.0000183597.31630.db

Gianino, A., & Tronick, E. Z. (1988). The mutual regulation model: The infant's self and interactive regulation and coping and defensive capacities. In *Stress and coping across development.* (pp. 47–68). Lawrence Erlbaum Associates, Inc.

Guedeney, A., Forhan, A., Larroque, B., de Agostini, M., Pingault, J.-B., & Heude, B. (2016). Social Withdrawal Behaviour at One Year of Age Is Associated with Delays in Reaching Language Milestones in the EDEN Mother-Child Cohort Study. *PLOS ONE*, *11*(7), e0158426. https://doi.org/10.1371/journal.pone.0158426

Huang, L., Zhao, Y., Qiang, C., & Fan, B. (2018). Is cognitive behavioral therapy a better choice for women with postnatal depression? A systematic review and meta-analysis. *PLoS ONE*, *13*(10). https://doi.org/10.1371/journal.pone.0205243

Jebb, A. T., Parrigon, S., & Woo, S. E. (2017). Exploratory data analysis as a foundation of inductive research. *Human Resource Management Review*. https://doi.org/10.1016/j.hrmr.2016.08.003

Jung, V., Short, R., Letourneau, N., Andrews, D., V., J., R., S., & N., L. (2007). Interventions with depressed mothers and their infants: Modifying interactive behaviours. *Journal of*

Affective Disorders, *98*(3), 199–205.

https://doi.org/http://dx.doi.org/10.1016/j.jad.2006.07.014

Katherine Weinberg, M., Olson, K. L., Beeghly, M., & Tronick, E. Z. (2006). Making up is hard to do, especially for mothers with high levels of depressive symptoms and their infant sons. *Journal of Child Psychology and Psychiatry*, *47*(7), 670–683. https://doi.org/10.1111/j.1469-7610.2005.01545.x

Kuczynski, L., & Kochanska, G. (1990). Development of Children's Noncompliance Strategies From Toddlerhood to Age 5. *Developmental Psychology*, *26*(3), 398–408. https://doi.org/10.1037/0012-1649.26.3.398

Leclère, C., Viaux, S., Avril, M., Achard, C., Chetouani, M., Missonnier, S., & Cohen, D. (2014). Why Synchrony Matters during Mother-Child Interactions: A Systematic Review. *PLoS ONE*, *9*(12), e113571. https://doi.org/10.1371/journal.pone.0113571

Little, R. J. A. (1988). A test of missing completely at random for multivariate data with missing values. *Journal of the American Statistical Association*, *83*(404), 1198–1202. https://doi.org/10.1080/01621459.1988.10478722

Lotzin, A., Romer, G., Schiborr, J., Noga, B., Schulte-Markwort, M., & Ramsauer, B. (2015). Gaze Synchrony between Mothers with Mood Disorders and Their Infants: Maternal Emotion Dysregulation Matters. *PLoS ONE*. https://doi.org/10.1371/journal.pone.0144417

Lovejoy, C. M., Graczyk, P. A., O'Hare, E., & Neuman, G. (2000). Maternal depression and

parenting behavior. *Clinical Psychology Review*, *20*(5), 561–592. https://doi.org/10.1016/S0272-7358(98)00100-7

Mayes, L. C., & Carter, A. S. (1990). Emerging Social Regulatory Capacities as Seen in the Still-Face Situation. *Child Development*. https://doi.org/10.2307/1130960

McHugh, M. L. (2012). Interrater reliability: The kappa statistic. *Biochemia Medica*, *22*(3), 276–282. https://doi.org/10.11613/bm.2012.031

Mesman, J., van IJzendoorn, M. H., & Bakermans-Kranenburg, M. J. (2009). The many faces of the Still-Face Task: A review and meta-analysis. *Developmental Review*, *29*(2), 120–162. https://doi.org/10.1016/j.dr.2009.02.001

Milne, L., Greenway, P., Guedeney, A., & Larroque, B. (2009). Long term developmental impact of social withdrawal in infants. *Infant Behavior and Development*. https://doi.org/10.1016/j.infbeh.2008.12.006

Moore, G. A., Cohn, J. F., & Campbell, S. B. (2001). Infant affective responses to mother's still face at 6 months differentially predict externalizing and internalizing behaviors at 18 months. *Developmental Psychology*. https://doi.org/10.1037/0012-1649.37.5.706

Muller, M., Tronick, E., Zietlow, A.-L., Nonnenmacher, N., Verschoor, S., & Trauble, B. (2016). Effects of Maternal Anxiety Disorders on Infant Self-Comforting Behaviors: The Role of Maternal Bonding, Infant Gender and Age. *Psychopathology*, *49*(4), 295–304. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med12&NEWS=N&AN=

27576511

Muller, M., Zietlow, A.-L., Tronick, E., Reck, C., M., M., A.-L., Z., & E., T. (2015). What Dyadic Reparation Is Meant to Do: An Association with Infant Cortisol Reactivity. *Psychopathology*, *48*(6), 386–399. https://doi.org/https://dx.doi.org/10.1159/000439225

Nadel, J., Soussignan, R., Canet, P., Libert, G., & Gérardin, P. (2005). Two-month-old infants of depressed mothers show mild, delayed and persistent change in emotional state after non-contingent interaction. *Infant Behavior and Development*, *28*(4), 418–425. https://doi.org/10.1016/j.infbeh.2005.03.005

Nazzari, S., Medea, E., De Carli, P., Zietlow, A.-L., Zietlow@, A.-L., Nonnenmacher, N., Reck, C., Ditzen, B., & Müller, M. (2019). *Emotional Stress During Pregnancy – Associations With Maternal Anxiety Disorders, Infant Cortisol Reactivity, and Mother–Child Interaction at Pre-school Age*. https://doi.org/10.3389/fpsyg.2019.02179

Noe, D., Schluckwerder, S., Reck, C., D., N., & S., S. (2015). Influence of dyadic matching of affect on infant self-regulation. *Psychopathology*, *48*(3), 173–183. https://doi.org/http://dx.doi.org/10.1159/000376586

O'Hara, M. W., & McCabe, J. E. (2013). Postpartum Depression: Current Status and Future Directions. *Annual Review of Clinical Psychology*. https://doi.org/10.1146/annurev-clinpsy-050212-185612

Oppenheimer, J. E., Measelle, J. R., Laurent, H. K., & Ablow, J. C. (2013). Mothers' vagal

regulation during the Still-Face Task: Normative reactivity and impact of depression symptoms. *Infant Behavior and Development*, *36*(2), 255–267. https://doi.org/10.1016/j.infbeh.2013.01.003

Paris, R., Bolton, R. E., & Weinberg, M. K. (2009). Postpartum depression, suicidality, and mother-infant interactions. *Archives of Women's Mental Health*. https://doi.org/10.1007/s00737-009-0105-2

Paulson, J. F., Dauber, S., & Leiferman, J. A. (2006). Individual and combined effects of postpartum depression in mothers and fathers on parenting behavior. *Pediatrics*. https://doi.org/10.1542/peds.2005-2948

Peláez-Nogueras, M., Field, T. M., Hossain, Z., & Pickens, J. (1996). Depressed Mothers' Touching Increases Infants' Positive Affect and Attention in Still-Face Interactions. *Child Development*. https://doi.org/10.1111/j.1467-8624.1996.tb01827.x

Reck, C., Noe, D., and Cenciotti, F. (2008). *Infant and Caregiver Engagement Phases Revised (ICEP-R) Coding Manual*.

Reck, C, Van Den Bergh, B., Tietz, A., Müller, M., Ropeter, A., Zipser, B., & Pauen, S. (2018). Maternal avoidance, anxiety cognitions and interactive behaviour predicts infant development at 12 months in the context of anxiety disorders in the postpartum period. *Infant Behavior & Development*, *50*, 116–131. https://doi.org/10.1016/j.infbeh.2017.11.007

Reck, Corinna, Tietz, A., Muller, M., Seibold, K., & Tronick, E. (2018). The impact of maternal

anxiety disorder on mother-infant interaction in the postpartum period. *PloS One*, *13*(5),

e0194763. https://doi.org/https://dx.doi.org/10.1371/journal.pone.0194763

Reck, Corinna, Tietz, A., Müller, M., Seibold, K., & Tronick, E. (2018). The impact of maternal

anxiety disorder on mother-infant interaction in the postpartum period. *PLoS ONE*, *13*(5).

https://doi.org/10.1371/journal.pone.0194763

Rouse, M. H., & Goodman, S. H. (2014). Perinatal depression influences on infant negative

affectivity: Timing, severity, and co-morbid anxiety. *Infant Behavior and Development*,

37(4), 739–751. https://doi.org/10.1016/j.infbeh.2014.09.001

Rubin, K. H., Coplan, R. J., & Bowker, J. C. (2009). Social Withdrawal in Childhood. *Annual

Review of Psychology*, *60*(1), 141–171.

https://doi.org/10.1146/annurev.psych.60.110707.163642

Sheehan, D. V., Lecrubier, Y., Sheehan, K. H., Amorim, P., Janavs, J., Weiller, E., Hergueta, T.,

Baker, R., & Dunbar, G. C. (1998). The Mini-International Neuropsychiatric Interview

(M.I.N.I.): The development and validation of a structured diagnostic psychiatric interview

for DSM-IV and ICD-10. *Journal of Clinical Psychiatry*, *59*(SUPPL. 20), 22–33.

Shorey, S., Chee, C. Y. I., Ng, E. D., Chan, Y. H., Tam, W. W. S., & Chong, Y. S. (2018).

Prevalence and incidence of postpartum depression among healthy mothers: A systematic

review and meta-analysis. *Journal of Psychiatric Research*, *104*(April), 235–248.

https://doi.org/10.1016/j.jpsychires.2018.08.001

Skotheim, S., Braarud, H. C., Høie, K., Markhus, M. W., Malde, M. K., Graff, I. E., Berle, J. Ø., & Stormark, K. M. (2013). Subclinical levels of maternal depression and infant sensitivity to social contingency. *Infant Behavior and Development*. https://doi.org/10.1016/j.infbeh.2013.03.009

Sockol, L. E., Epperson, C. N., & Barber, J. P. (2011). A meta-analysis of treatments for perinatal depression. *Clinical Psychology Review*, *31*(5), 839–849. https://doi.org/10.1016/j.cpr.2011.03.009

Sravish, A. V, Tronick, E., Hollenstein, T., & Beeghly, M. (2013). Dyadic Flexibility during the Face-to-Face Still-Face Task: A dynamic systems analysis of its temporal organization. *Infant Behavior & Development*, *36*(3), 432–437. https://doi.org/10.1016/j.infbeh.2013.03.013

Stanley, C., Murray, L., & Stein, A. (2004). The effect of postnatal depression on mother-infant interaction, infant response to the Still-face perturbation, and performance on an Instrumental Learning task. *Development and Psychopathology*, *16*(1), 1–18. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medc&NEWS=N&AN=15115062

Tronick, E., Als, H., Adamson, L., Wise, S., & Brazelton, T. B. (1978). The Infant's Response to Entrapment between Contradictory Messages in Face-to-Face Interaction. *Journal of the American Academy of Child Psychiatry*, *17*(1), 1–13. https://doi.org/10.1016/S0002-7138(09)62273-1

Tronick, E., & Reck, C. (2009). Infants of depressed mothers. *Harvard Review of Psychiatry*, *17*(2), 147–156. https://doi.org/10.1080/10673220902899714

Tronick, E. Z., & Weinberg, K. M. (1997). Depressed mothers and infants: Failure to form dyadic states of consciousness. In *Postpartum depression and child development*.

Tronick, E. Z., Weinberg, M. K., Seifer, R., Shankaran, S., Wright, L. L., Messinger, D. S., Lester, B. M., LaGasse, L., Bauer, C. R., Bada, H., Poole, K., & Liu, J. (2005). Cocaine exposure is associated with subtle compromises of infants' and mothers' social-emotional behavior and dyadic features of their interaction in the face-to-face still-face task. *Developmental Psychology*, *41*(5), 711–722. https://doi.org/10.1037/0012-1649.41.5.711

Van Lieshout, R. J., Yang, L., Haber, E., & Ferro, M. A. (2017). Evaluating the effectiveness of a brief group cognitive behavioural therapy intervention for perinatal depression. *Archives of Women's Mental Health*. https://doi.org/10.1007/s00737-016-0666-9

Vieites, V., & Reeb-Sutherland, B. C. (2017). Individual differences in non-clinical maternal depression impact infant affect and behavior during the still-face task across the first year. *Infant Behavior and Development*. https://doi.org/10.1016/j.infbeh.2017.02.005

Weinberg, M. K., & Tronick, E. Z. (1998). Infant and caregiver engagement phases system. *Boston, MA: Harvard Medical School*.

Supplemental Data

Table S1: Differences between those with and without complete FFSF data at all three visits

	PPD group [a]			Healthy control group [b]		
	Completed FFSF task at all visits	FFSF data missing at one of the three visits	*P*	Completed FFSF task at all visits	FFSF data missing at one of the three visits	*P*
Infant age at enrollment, M (SD), months	5.4 (2.4)	5.7 (3.3)	0.75	5.1(2.6)	5.9 (2.7)	0.42
Infant sex, No. (%), male	7 (32.0)	6 (66.7)	0.07	8 (42.1)	5 (45.4)	0.86
Total household income (CAD) M (SD) **<49,999** **50,000-79,999** **>80,000**	4 (18.1) 5 (22.7) 13 (59.1)	0 (0.0) 3 (33.3) 6 (66.6)	0.37	4 (21.1) 4 (21.1) 11 (57.8)	0 (0.0) 3 (27.3) 8 (72.7)	0.26
Maternal age, M (SD), years	32.3 (3.4)	32.6 (5.1)	0.86	33.0 (5.6)	31.4 (2.9)	0.44
Parity, No. (%), **Primiparous** **Multiparous**	10 (45.4) 12 (54.4)	6 (66.6) 3 (33.3)	0.28	9 (47.3) 10 (52.6)	7 (63.6) 4 (36.3)	0.39
Marital Status, No. (%), **Single** **Separated** **Common-law** **Married**	 1 (4.5) 6 (27.2) 15 (68.1)	 1 (11.1) 2 (22.2) 6 (66.6)	0.78	 1 (5.3) 4 (21.1) 14 (73.6)	 0 (0.0) 0 (0.0) 11 (100.0)	0.11
Education, No. (%), **High school or less** **College or certificate program** **University or higher**	1 (4.5) 10 (45.4) 11 (0.5)	1 (11.1) 1 (11.1) 7 (77.8)	0.18	1 (5.3) 7 (36.8) 11 (57.8)	0 (0.0) 1 (9.0) 10 (91.0)	0.16
Birthweight M (SD), grams	3292.7 (537.0)	3363.6 (224.7)	0.71	3325.5 (524.7)	3467.9 (360.2)	0.43
Gestational age at delivery M (SD), weeks	39.6 (2.7)	39.2 (1.4)	0.69	39.2 (0.9)	39.5 (0.74)	0.33

M: Mean
SD: Standard Deviation
CAD: Canadian Dollars
[a] There were 4 PPD group dyads that completed all three visits, however, since the FFSF task was added to the protocol after these dyads completed visit 2, they are not included
[b] 3 healthy control dyads completed all three visits but were examined before the FFSF task was added to the protocol

Table S2: Maternal Outcomes During the Face-to-Face Still-Face Task

	Pre-treatment M (SE)		Immediately post-treatment M (SE)		Three months post-treatment M (SE)	
	PPD	Controls	PPD	Controls	PPD	Controls
Play Phase						
Social Positive Engagement	75.6 (12.1)	64.9 (10.9)	85.1 (6.6)	92.7 (6.0)	77.0 (9.6)	83.8 (8.7)
Social Monitor (Positive Vocalizations)	17.2 (11.1)	26.3 (10.0)	14.9 (5.9)	1.9 (5.3)	22.9 (9.4)	13.4 (8.5)
Social Monitor (No/ Neutral Vocalizations)	1.0 (5.1)	7.5 (4.6)	0.1 (0.3)	0.3 (0.3)	0.5 (1.2)	2.2 (1.1)
Reunion Phase						
Social Positive Engagement	61.0 (12.4)	70.9 (11.1)	89.1 (10.0)	72.3 (9.0)	83.8 (8.4)	82.5 (7.6)
Social Monitor (Positive Vocalizations)	31.1 (11.6)	25.1 (10.4)	11.4 (8.1)	11.9 (7.3)	8.9 (5.5)	11.5 (5.0)
Social Monitor (No/ Neutral Vocalizations)	7.3 (4.9)	1.6 (4.5)	0.5 (2.2)	2.5 (2.0)	0.9 (4.1)	4.4 (3.7)

Percentage of time for mother behavioral outcomes in play and reunion phases, and at each visit
M: Mean
SE: Standard Error

CHAPTER FOUR: GENERAL DISCUSSION

The objective of this thesis was to determine the implications of maternal PPD on mothers, their infants and the mother-infant relationship. This was explored by examining the differences and trajectories of infant, maternal and mother-infant FFSF outcomes between mother-infant dyads affected by PPD and/or PPA versus healthy control dyads. The first study was conducted to determine if there were differences in infant and maternal behaviour between dyads exposed to PPD and healthy control dyads at each phase of the FFSF task. Since postpartum anxiety (PPA) is a common comorbidity of PPD, we also investigated the differences between mother-infant dyads affected by PPA, comorbid PPD and PPA, and healthy control dyads. Additionally, the potential changes in mother and infant behaviour after CBT treatment for PPD using the FFSF task was explored. In this study, the FFSF performance of mothers with PPD and their infants were evaluated at baseline (before CBT), immediately after CBT (nine weeks from baseline) and three months after CBT to observe potential changes when compared to non-depressed dyads.

In the first study, the systematic review and meta-analysis indicated that the mothers affected by PPD, together with their infants, might respond differently to the FFSF task compared to nondepressed dyads. Accurately, the infants of mothers with PPD appear to display fewer positive emotions at the play and reunion phases of the FFSF task when compared to infants of healthy mothers. Also, mothers with PPD might show less positive affect at the reunion phase, and mother-infant dyads in this group also potentially display less positive affective matching at the play phase in comparison to healthy control dyads. It is plausible that lower levels of

maternal sensitivity among women with PPD explain this finding, as mothers with PPD are less able to foster face-to-face interactions compared to healthy non-depressed mothers (Brummelte & Galea, 2016; E. Tronick & Reck, 2009). Furthermore, it appears that the infants of mothers with PPA or comorbid PPD and PPA also show different patterns of behaviour when completing the FFSF task. While the infants of mothers with PPA engage more with objects and their surroundings, the infants of mothers with comorbid PPD and PPA show more object/environment engagements at both the play and reunion phases versus the infants of healthy nondepressed mothers. Object/environment engagement illustrates infant self-regulation, and its pronounced presence at an early stage in infancy may be a marker for the infants' familiarity with maternal emotional unavailability (Manian & Bornstein, 2009).

The review also suggested that there were no differences in specific infant, maternal and mother-infant dyadic FFSF outcomes between mothers with PPD and/or PPA and their infants. These outcomes included infant neutral affect, self-comforting behaviours, gaze aversion, negative affect, as well as maternal positive affect, neutral affect, negative affect. There were also no statistically significant differences in dyadic mismatching and flexibility. These surprising null findings could be attributed to the relatively small number of studies included in the systematic review and meta-analysis which is connected to the few studies have been conducted using samples of mothers with PPD and/or PPA and their infants on the FFSF task (Graham et al., 2018; Mesman et al., 2009; E. Tronick & Reck, 2009). Further, the heterogeneity in disorders classified under PPA including generalized anxiety disorder, obsessive-compulsive disorder and social phobia may be responsible for the lack of statistically significant differences

between mothers with PPA alone or comorbid PPD and PPA and their infants and healthy control dyads (Corinna Reck et al., 2018).

The results of the second study suggested that three months after maternal PPD treatment using CBT, the infants of depressed mothers displayed lower levels of withdrawn behaviour, which normalized to levels observed among the infants of non-depressed healthy mothers. At the baseline and immediate post-treatment assessment, the infants of mothers with PPD had significantly higher levels of withdrawn behaviour during the still-face phase of the FFSF task. However, the withdrawn behaviour in the infants of mothers with PPD was effectively reduced and normalized to the levels of the infants of healthy control mothers at three months post-CBT treatment. These findings suggest that CBT may be capable of improving infant outcomes by reducing maladaptive, withdrawn infant behaviour to normal levels. This is a critical insight given that infant withdrawn behaviour is the most researched outcome in studies examining the impact of maternal PPD on infant behaviour and this withdrawn behaviour has been linked to future developmental challenges such as cognitive problems and psychopathology in childhood and adolescence (Bernard-Bonnin, 2004; Milne et al., 2009).

It should be noted that the analyses in the second study demonstrated no changes in other infant and maternal FFSF outcomes, including infant social positive engagement, social monitor, object/environment engagement and protesting. The same was observed for positive maternal engagement, no/neutral vocalizations and positive vocalizations. One explanation for these unexpected findings is that the FFSF task may be incapable of detecting changes in these specific outcomes after maternal treatment of PPD. As the review study presented in this thesis

suggested, some FFSF task outcomes may not be noticeably different, or unable to reliably capture differences between mother-infant dyads involving mothers with PPD and healthy control dyads. It is also possible that the maternal CBT treatment is unable to produce changes in these behaviours, and the specific treatment of infants or the mother-infant dyad instead of mothers alone may be required.

Together, these studies provide knowledge on the potential impact of maternal mood disorders like PPD and/or PPA on infants, mothers and the mother-infant relationship. The studies included in this thesis summarized the literature to address the critical issue of whether PPD and/or PPA affect mother-infant relations differently on the FFSF task, in comparison to healthy control dyads. The review further attempted to explore whether the effects of PPD and PPA comorbidity translated to worse FFSF outcomes compared to either one individually. The meta-analyses suggested that maternal PPD, PPA and comorbid PPD and PPA affect infant, maternal and dyadic outcomes, compared to healthy dyads. These results may be useful to the field of developmental psychology as they highlight the different effects of PPD, PPA and comorbid PPD and PPA, which can help inform future clinical research.

The studies contained in this thesis also highlight the potential benefits and drawbacks of the widely used FFSF task. The FFSF task is a robust and valid observational instrument that has been used in different demographic and risk-variable samples (Adamson & Frick, 2003; Mesman et al., 2009; Ginger A. Moore et al., 2009). Studies have indicated that the FFSF task can measure the quality of dyadic interactions between infants and caregivers, and even strangers (Mesman et al., 2009). Despite this, one notable drawback of the FFSF task is the high

probability of mothers modifying their behaviour due to their awareness of being observed (i.e., social desirability bias) (Lovejoy et al., 2000; Reck et al., 2018b; Vieites and Reeb-Sutherland, 2017). In addition, there appears to be an inconsistent use of the FFSF task as many studies use heavily modified versions of the task, such as the addition of a 'separation' period or have two still-face phases, which introduces heterogeneity in how the FFSF is implemented. These variations may translate into incongruent results when attempting to characterize FFSF outcomes across multiple studies. Also, despite its validity, the FFSF task has been rarely implemented in clinical studies. Indeed, the second study included within this thesis is one of the few studies that have attempted to measure the therapeutic alterations in behaviour using the FFSF task. Though our research showed that the FFSF might be capable of capturing these changes, more studies are required to solidify these findings.

To help the FFSF task achieve its full potential future studies examining the impact of maternal PPD and/or PPA on the quality of mother-infant interactions and mutual regulation should test the effects of comorbid PPD and PPA in addition to PPD or PPA alone. This is a less-researched area within the current body of FFSF task literature and requires more attention as comorbid PPD and PPA may pose an even higher risk to infant, maternal and dyadic behavioural outcomes due to its prevalence and severity (Andrews et al., 2000; Dennis et al., 2018; C. Reck et al., 2008). Future studies should also focus on presenting more descriptive analysis in the body of the text or supplementary data to make concise summaries and synthesis of data more robust and conclusive. Furthermore, future studies should investigate the influence of specific postpartum anxiety disorders (like generalized anxiety disorder and obsessive-compulsive

disorder) have on infant, maternal and dyadic FFSF outcomes, as these disorders have distinctive effects on mothers. Also, it would be beneficial to the general understanding of the FFSF outcomes if future experimental studies adopted the FFSF task as a tool for evaluating the quality of the mother-infant relationship in clinical studies involving mothers with PPD and/or PPA and their infants. This could also provide more information on the potential of the FFSF task to detect changes and stability of infant, maternal and dyadic behaviours and coordination after an intervention. Finally, more studies should explore how other caregivers, such as fathers interact with their infants since relatively few studies have been conducted in this area. A greater investigation into the roles of other caregivers and their interactions with infants could help provide more holistic evidence and a profound understanding of infant socio-emotional development.

In conclusion, this thesis illustrates the importance of investigating the effects of maternal PPD and/or PPA on infant, maternal and dyadic FFSF behavioural outcomes. It appears that mothers with PPD, PPA and comorbid PPD and PPA (and their infants) behave differently during the FFSF task in some important FFSF outcomes in comparison with healthy control dyads. Mothers with PPD and their infants may engage less positively on the FFSF task and subsequently exhibit lower levels of positive affective matching compared to healthy mothers and their infants. Additionally, the infants of mothers with PPA and comorbid PPD and PPA appear to display more object/environment engagement versus the infants of healthy mothers. Moreover, the benefits of CBT for mothers with PPD may extend to their infants as it reduces maladaptive infant behaviour (i.e., withdrawn behaviour) to normal levels. The validity and

robustness of the FFSF task as a tool for assessing the quality of mother-infant interactions is further solidified with this work. Overall, to advance the field even further, considerable research should be conducted on the impact of comorbid PPD and PPA, and implement the FFSF task in experimental designs. Viewed in its totality, the FFSF task holds promise for an in-depth understanding of the influence of maternal psychopathology (PPD and/or PPA) on the mothers, the mother-infant relationship, and, subsequently, infant behavioural outcomes across the lifespan.

References

Adamson, L. B., & Frick, J. E. (2003). The still face: A history of a shared experimental

    paradigm. In *Infancy*. https://doi.org/10.1207/S15327078IN0404_01

Ammerman, R. T., Putnam, F. W., Altaye, M., Stevens, J., Teeters, A. R., & Van Ginkel, J. B.

    (2013). A Clinical Trial of In-Home CBT for Depressed Mothers in Home Visitation.

    Behavior Therapy. https://doi.org/10.1016/j.beth.2013.01.002

Andrews, G., Sanderson, K., Slade, T., & Issakidis, C. (2000). Why does the burden of disease

    persist? Relating the burden of anxiety and depression to effectiveness of treatment. *Bulletin*

    of the World Health Organization. https://doi.org/10.1080/000486700536

Azak, S. (2012). Maternal depression and sex differences shape the infants' trajectories of

    cognitive development. *Infant Behavior and Development*.

    https://doi.org/10.1016/j.infbeh.2012.07.017

Beardslee, W. R., Versage, E. M., & Gladstone, T. R. G. (1998). Children of affectively Ill

    parents: A review of the past 10 years. In *Journal of the American Academy of Child and*

    Adolescent Psychiatry. https://doi.org/10.1097/00004583-199811000-00012

Beck, A. T. (1997). The past and future of cognitive therapy. *Journal of Psychotherapy Practice*

    and Research.

Beck, C. T. (2001). Predictors of postpartum depression: An update. *Nursing Research*.

https://doi.org/10.1097/00006199-200109000-00004

Bernard-Bonnin, A.-C. (2004). Maternal depression and child development. *Paediatrics & Child Health*, *9*(8), 575. https://doi.org/10.1093/pch/9.8.575

Brummelte, S., & Galea, L. A. M. (2016). Postpartum depression: Etiology, treatment and consequences for maternal care. *Hormones and Behavior*. https://doi.org/10.1016/j.yhbeh.2015.08.008

Butler, A. C., Chapman, J. E., Forman, E. M., & Beck, A. T. (2006). The empirical status of cognitive-behavioral therapy: A review of meta-analyses. *Clinical Psychology Review*, *26*, 17–31. https://doi.org/10.1016/j.cpr.2005.07.003

Campbell, S. B., & Cohn, J. F. (1997). The timing and chronicity of postpartum depression: Implications for infant development. In *Postpartum depression and child development.* (pp. 165–197). Guilford Press.

Carter, A. S., Garrity-Rokous, F. E., Chazan-Cohen, R., Little, C., & Briggs-Gowan, M. J. (2001). Maternal depression and comorbidity: Predicting early parenting, attachment security, and toddler social-emotional problems and competencies. *Journal of the American Academy of Child and Adolescent Psychiatry*, *40*(1), 18–26. https://doi.org/10.1097/00004583-200101000-00012

Chabrol, H., Teissedre, F., Saint-Jean, M., Teisseyre, N., Rogé, B., & Mullet, E. (2002). Prevention and treatment of post-partum depression: A controlled randomized study on

women at risk. *Psychological Medicine*. https://doi.org/10.1017/S0033291702006062

Dagher, R. K., Hofferth, S. L., & Lee, Y. (2014). Maternal depression, pregnancy intention, and return to paid work after childbirth. *Women's Health Issues*. https://doi.org/10.1016/j.whi.2014.03.002

de Rosnay, M., Cooper, P. J., Tsigaras, N., & Murray, L. (2006). Transmission of social anxiety from mother to infant: An experimental study using a social referencing paradigm. *Behaviour Research and Therapy*. https://doi.org/10.1016/j.brat.2005.09.003

Dennis, C. L., Brown, H. K., Wanigaratne, S., Fung, K., Vigod, S. N., Grigoriadis, S., Marini, F., & Brennenstuhl, S. (2018). Prevalence, Incidence, and Persistence of Postpartum Depression, Anxiety, and Comorbidity among Chinese Immigrant and Nonimmigrant Women: A Longitudinal Cohort Study. *Canadian Journal of Psychiatry*. https://doi.org/10.1177/0706743717720689

Do, T., Hu, Z., Otto, J., & Rohrbeck, P. (2013). Depression and suicidality during the postpartum period after first time deliveries, active component service women and dependent spouses, U.S. Armed Forces, 2007-2012. *MSMR*.

Driessen, E., & Hollon, S. D. (2010). Cognitive behavioral therapy for mood disorders: Efficacy, moderators and mediators. In *Psychiatric Clinics of North America*. https://doi.org/10.1016/j.psc.2010.04.005

Farr, S. L., Dietz, P. M., O'Hara, M. W., Burley, K., & Ko, J. Y. (2014). Postpartum anxiety and

comorbid depression in a population-based sample of women. *Journal of Women's Health*. https://doi.org/10.1089/jwh.2013.4438

Feldman, R., Granat, A., Pariente, C., Kanety, H., Kuint, J., & Gilboa-Schechtman, E. (2009). Maternal Depression and Anxiety Across the Postpartum Year and Infant Social Engagement, Fear Regulation, and Stress Reactivity. *Journal of the American Academy of Child and Adolescent Psychiatry*. https://doi.org/10.1097/CHI.0b013e3181b21651

Field, T. (2010). Postpartum depression effects on early interactions, parenting, and safety practices: A review. In *Infant Behavior and Development*. https://doi.org/10.1016/j.infbeh.2009.10.005

Field, T. (2017). Postpartum Anxiety Prevalence, Predictors and Effects on Child Development: A Review. *Journal of Psychiatry and Psychiatric Disorders*. https://doi.org/10.26502/jppd.2572-519x0010

Field, T., Diego, M., Hernandez-Reif, M., Figueiredo, B., Deeds, O., Ascencio, A., Schanberg, S., & Kuhn, C. (2010). Comorbid depression and anxiety effects on pregnancy and neonatal outcome. *Infant Behavior and Development*. https://doi.org/10.1016/j.infbeh.2009.10.004

Field, T., Hernandez-Reif, M., Diego, M., Feijo, L., Vera, Y., Gil, K., & Sanders, C. (2007). Still-face and separation effects on depressed mother-infant interactions. *Infant Mental Health Journal*. https://doi.org/10.1002/imhj.20138

Forbes, E. E., Cohn, J. F., Allen, N. B., & Lewinsohn, P. M. (2004). Infant affect during parent-

infant interaction at 3 and 6 months: Differences between mothers and fathers and influence of parent history of depression. *Infancy*. https://doi.org/10.1207/s15327078in0501_3

Gianino, A., & Tronick, E. Z. (1988). The mutual regulation model: The infant's self and interactive regulation and coping and defensive capacities. In *Stress and coping across development.* (pp. 47–68). Lawrence Erlbaum Associates, Inc.

Goodman, J. H., & Santangelo, G. (2011). Group treatment for postpartum depression: A systematic review. In *Archives of Women's Mental Health*. https://doi.org/10.1007/s00737-011-0225-3

Graham, K. A., Blissett, J., Antoniou, E. E., Zeegers, M. P., McCleery, J. P., K.A., G., J., B., E.E., A., & M.P., Z. (2018). Effects of maternal depression in the Still-Face Paradigm: A meta-analysis. *Infant Behavior and Development*, *50*, 154–164. https://doi.org/http://dx.doi.org/10.1016/j.infbeh.2017.12.001

Hanington, L., Ramchandani, P., & Stein, A. (2010). Parental depression and child temperament: Assessing child to parent effects in a longitudinal population study. *Infant Behavior and Development*. https://doi.org/10.1016/j.infbeh.2009.11.004

Horowitz, J. A., & Goodman, J. (2004). A longitudinal study of maternal postpartum depression symptoms. *Research and Theory for Nursing Practice*. https://doi.org/10.1891/rtnp.18.2.149.61285

Howard, L. M., Ryan, E. G., Trevillion, K., Anderson, F., Bick, D., Bye, A., Byford, S.,

O'Connor, S., Sands, P., Demilew, J., Milgrom, J., & Pickles, A. (2018). Accuracy of the Whooley questions and the Edinburgh Postnatal Depression Scale in identifying depression and other mental disorders in early pregnancy. *British Journal of Psychiatry*. https://doi.org/10.1192/bjp.2017.9

Huang, L., Zhao, Y., Qiang, C., & Fan, B. (2018). Is cognitive behavioral therapy a better choice for women with postnatal depression? A systematic review and meta-analysis. *PLoS ONE*, *13*(10). https://doi.org/10.1371/journal.pone.0205243

Kalita, K. N. (2010). Developmental profile of infants born to mothers with postpartum depression and anxiety: A comparative study. *Journal of Indian Association for Child and Adolescent Mental Health*.

Katherine Weinberg, M., Olson, K. L., Beeghly, M., & Tronick, E. Z. (2006). Making up is hard to do, especially for mothers with high levels of depressive symptoms and their infant sons. *Journal of Child Psychology and Psychiatry*, *47*(7), 670–683. https://doi.org/10.1111/j.1469-7610.2005.01545.x

Kingston, D., Kehler, H., Austin, M. P., Mughal, M. K., Wajid, A., Vermeyden, L., Benzies, K., Brown, S., Stuart, S., & Giallo, R. (2018). Trajectories of maternal depressive symptoms during pregnancy and the first 12 months postpartum and child externalizing and internalizing behavior at three years. *PLoS ONE*. https://doi.org/10.1371/journal.pone.0195365

Koester, L. S. (1995). Face-to-face interactions between hearing mothers and their deaf or

hearing infants. *Infant Behavior and Development*. https://doi.org/10.1016/0163-

6383(95)90044-6

Koester, L. S., & Meadow-Orlans, K. P. (1999). Responses to interactive stress: Infants who are

deaf or hearing. *American Annals of the Deaf*. https://doi.org/10.1353/aad.2012.0185

Lanzi, R. G., Bert, S. C., & Jacobs, B. K. (2009). Depression among a sample of first-time

adolescent and adult mothers. *Journal of Child and Adolescent Psychiatric Nursing*.

https://doi.org/10.1111/j.1744-6171.2009.00199.x

Lilja, G., Edhborg, M., & Nissen, E. (2012). Depressive mood in women at childbirth predicts

their mood and relationship with infant and partner during the first year postpartum.

Scandinavian Journal of Caring Sciences. https://doi.org/10.1111/j.1471-

6712.2011.00925.x

Logsdon, M. C., Wisner, K. L., & Pinto-Foltz, M. D. (2006). The impact of postpartum

depression on mothering. *JOGNN - Journal of Obstetric, Gynecologic, and Neonatal

Nursing*, *35*(5), 652–658. https://doi.org/10.1111/j.1552-6909.2006.00087.x

Lovejoy, C. M., Graczyk, P. A., O'Hare, E., & Neuman, G. (2000). Maternal depression and

parenting behavior. *Clinical Psychology Review*, *20*(5), 561–592.

https://doi.org/10.1016/S0272-7358(98)00100-7

M.P., A., & K.A., G. (2008). The association between prenatal maternal anxiety and infant

hypothalamic pituitary adrenal axis function. *European Neuropsychopharmacology*, *18*(S4), S554.

http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=emed10&NEWS=N&AN=70061403

Madden, V., Domoney, J., Aumayer, K., Sethna, V., Iles, J., Hubbard, I., Giannakakis, A., Psychogiou, L., & Ramchandani, P. (2015). Intergenerational transmission of parenting: Findings from a UK longitudinal study. *European Journal of Public Health*.
https://doi.org/10.1093/eurpub/ckv093

Manian, N., & Bornstein, M. H. (2009). Dynamics of emotion regulation in infants of clinically depressed and nondepressed mothers. *Journal of Child Psychology and Psychiatry and Allied Disciplines*. https://doi.org/10.1111/j.1469-7610.2009.02166.x

Mesman, J., van IJzendoorn, M. H., & Bakermans-Kranenburg, M. J. (2009). The many faces of the Still-Face Paradigm: A review and meta-analysis. *Developmental Review*, *29*(2), 120–162. https://doi.org/10.1016/j.dr.2009.02.001

Milne, L., Greenway, P., Guedeney, A., & Larroque, B. (2009). Long term developmental impact of social withdrawal in infants. *Infant Behavior and Development*.
https://doi.org/10.1016/j.infbeh.2008.12.006

Mitchell, E. A., Nuttall, A. K., & Wittenborn, A. (2019). Maternal Depressive Symptoms and Warm Responsiveness Across the Transition to Parenthood. *Journal of Child and Family*

Studies, *28*(6), 1604–1612. https://doi.org/10.1007/s10826-019-01392-x

Moehler, E., Brunner, R., Wiebel, A., Reck, C., & Resch, F. (2006). Maternal depressive symptoms in the postnatal period are associated with long-term impairment of mother-child bonding. *Archives of Women's Mental Health*. https://doi.org/10.1007/s00737-006-0149-5

Moore, G. A., Cohn, J. F., & Campbell, S. B. (2001). Infant affective responses to mother's still face at 6 months differentially predict externalizing and internalizing behaviors at 18 months. *Developmental Psychology*. https://doi.org/10.1037/0012-1649.37.5.706

Moore, Ginger A., Hill-Soderlund, A. L., Propper, C. B., Calkins, S. D., Mills-Koonce, W. R., & Cox, M. J. (2009). Mother-infant vagal regulation in the face-to-face still-face paradigm is moderated by maternal sensitivity. *Child Development*. https://doi.org/10.1111/j.1467-8624.2008.01255.x

Murray, L., Cooper, P., Creswell, C., Schofield, E., & Sack, C. (2007). The effects of maternal social phobia on mother-infant interactions and infant social responsiveness. *Journal of Child Psychology and Psychiatry and Allied Disciplines*. https://doi.org/10.1111/j.1469-7610.2006.01657.x

Murray, L., Cooper, P. J., Wilson, A., & Romaniuk, H. (2003). Controlled trial of the short- and long-term effect of psychological treatment of post-partum depression. 2. Impact on the mother-child relationship and child outcome. *British Journal of Psychiatry*. https://doi.org/10.1192/bjp.182.5.420

Murray, L., Halligan, S. L., Adams, G., Patterson, P., & Goodyer, I. M. (2006). Socio-emotional development in adolescents at risk for depression: The role of maternal depression and attachment style. *Development and Psychopathology*. https://doi.org/10.1017/S0954579406060263

Nagy, E., Pilling, K., Watt, R., Pal, A., & Orvos, H. (2017). Neonates' responses to repeated exposure to a still face. *PLoS ONE*. https://doi.org/10.1371/journal.pone.0181688

Park, E. R., Chang, Y., Quinn, V., Regan, S., Cohen, L., Viguera, A., Psaros, C., Ross, K., & Rigotti, N. (2009). The association of depressive, anxiety, and stress symptoms and postpartum relapse to smoking: A longitudinal study. *Nicotine and Tobacco Research*. https://doi.org/10.1093/ntr/ntp053

Peláez-Nogueras, M., Field, T. M., Hossain, Z., & Pickens, J. (1996). Depressed Mothers' Touching Increases Infants' Positive Affect and Attention in Still-Face Interactions. *Child Development*. https://doi.org/10.1111/j.1467-8624.1996.tb01827.x

Piteo, A. M., Yelland, L. N., & Makrides, M. (2012). Does maternal depression predict developmental outcome in 18month old infants? *Early Human Development*. https://doi.org/10.1016/j.earlhumdev.2012.01.013

Pope, C. J., Xie, B., Sharma, V., & Campbell, M. K. (2013). A prospective study of thoughts of self-harm and suicidal ideation during the postpartum period in women with mood disorders. *Archives of Women's Mental Health*. https://doi.org/10.1007/s00737-013-0370-y

Posmontier, B. (2008). Functional Status Outcomes in Mothers With and Without Postpartum Depression. *Journal of Midwifery and Women's Health*. https://doi.org/10.1016/j.jmwh.2008.02.016

Prenoveau, J., Craske, M., Counsell, N., West, V., Davies, B., Cooper, P., Rapa, E., & Stein, A. (2013). Postpartum GAD is a risk factor for postpartum MDD: The course and longitudinal relationships of postpartum GAD and MDD. *Depression and Anxiety*. https://doi.org/10.1002/da.22040

Reck, C., Struben, K., Backenstrass, M., Stefenelli, U., Reinig, K., Fuchs, T., Sohn, C., & Mundt, C. (2008). Prevalence, onset and comorbidity of postpartum anxiety and depressive disorders. *Acta Psychiatrica Scandinavica*. https://doi.org/10.1111/j.1600-0447.2008.01264.x

Reck, Corinna, Noe, D., Stefenelli, U., Fuchs, T., Cenciotti, F., Stehle, E., Mundt, C., Downing, G., Tronick, E. Z., C., R., D., N., U., S., T., F., F., C., E., S., C., M., & G., D. (2011). Interactive coordination of currently depressed inpatient mothers and their infants during the postpartum period. *Infant Mental Health Journal*, *32*(5), 542–562. https://doi.org/http://dx.doi.org/10.1002/imhj.20312

Reck, Corinna, Tietz, A., Müller, M., Seibold, K., & Tronick, E. (2018). The impact of maternal anxiety disorder on mother-infant interaction in the postpartum period. *PLoS ONE*, *13*(5). https://doi.org/10.1371/journal.pone.0194763

Rosenblum, K. L., McDonongh, S., Mnzik, M., Miller, A., & Sameroff, A. (2002). Maternal

representations of the infant: Associations with infant response to the still face. *Child

Development*. https://doi.org/10.1111/1467-8624.00453

Ross, L. E., & McLean, L. M. (2006). Anxiety disorders during pregnancy and the postpartum

period: A systematic review. *Journal of Clinical Psychiatry*.

https://doi.org/10.4088/JCP.v67n0818

S. Hairston, I., E. Handelzalts, J., Assis, C., & Kovo, M. (2018). POSTPARTUM BONDING

DIFFICULTIES AND ADULT ATTACHMENT STYLES: THE MEDIATING ROLE OF

POSTPARTUM DEPRESSION AND CHILDBIRTH-RELATED PTSD. *Infant Mental

Health Journal*. https://doi.org/10.1002/imhj.21695

Scope, A., Leaviss, J., Kaltenthaler, E., Parry, G., Sutcliffe, P., Bradburn, M., & Cantrell, A.

(2013). Is group cognitive behaviour therapy for postnatal depression evidence-based

practice? A systematic review. *BMC Psychiatry*. https://doi.org/10.1186/1471-244X-13-321

Shorey, S., Chee, C. Y. I., Ng, E. D., Chan, Y. H., Tam, W. W. S., & Chong, Y. S. (2018).

Prevalence and incidence of postpartum depression among healthy mothers: A systematic

review and meta-analysis. *Journal of Psychiatric Research*, *104*(April), 235–248.

https://doi.org/10.1016/j.jpsychires.2018.08.001

Slomian, J., Honvo, G., Emonts, P., Reginster, J. Y., & Bruyère, O. (2019). Consequences of

maternal postpartum depression: A systematic review of maternal and infant outcomes. In

Women's Health. https://doi.org/10.1177/1745506519844044

Sockol, L. E., Epperson, C. N., & Barber, J. P. (2011). A meta-analysis of treatments for

perinatal depression. *Clinical Psychology Review*, *31*(5), 839–849.

https://doi.org/10.1016/j.cpr.2011.03.009

Stanley, C., Murray, L., & Stein, A. (2004). The effect of postnatal depression on mother-infant

interaction, infant response to the Still-face perturbation, and performance on an

Instrumental Learning task. *Development and Psychopathology*, *16*(1), 1–18.

http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medc&NEWS=N&AN=1

5115062

Stevenson, M. D., Scope, A., Sutcliffe, P. A., Booth, A., Slade, P., Parry, G., Saxon, D., &

Kalthenthaler, E. (2010). Group cognitive behavioural therapy for postnatal depression: A

systematic review of clinical effectiveness, costeffectiveness and value of information

analyses. In *Health Technology Assessment*. https://doi.org/10.3310/hta14440

Stewart, D. E., Robertson, E., Phil, M., Dennis, C., Grace, S. L., & Wallington, T. (2003).

Postpartum Depression: Literature review of risk factors and interventions. *WHO*

Publication.

Taylor, J., & Johnson, M. (2013). The role of anxiety and other factors in predicting postnatal

fatigue: From birth to 6 months. *Midwifery*. https://doi.org/10.1016/j.midw.2012.04.011

Toth, S. L., Rogosch, F. A., Sturge-Apple, M., & Cicchetti, D. (2009). Maternal depression,

children's attachment security, and representational development: An organizational

perspective. *Child Development*. https://doi.org/10.1111/j.1467-8624.2008.01254.x

Tronick, E., Als, H., Adamson, L., Wise, S., & Brazelton, T. B. (1978). The Infant's Response to

Entrapment between Contradictory Messages in Face-to-Face Interaction. *Journal of the

American Academy of Child Psychiatry*, *17*(1), 1–13. https://doi.org/10.1016/S0002-

7138(09)62273-1

Tronick, E., & Reck, C. (2009). Infants of depressed mothers. *Harvard Review of Psychiatry*,

17(2), 147–156. https://doi.org/10.1080/10673220902899714

Tronick, E. Z., & Gianino, A. (1986). Interactive mismatch and repair: Challenges to the coping

infant. *Zero to Three*.

Van Lieshout, R. J., Yang, L., Haber, E., & Ferro, M. A. (2017). Evaluating the effectiveness of

a brief group cognitive behavioural therapy intervention for perinatal depression. *Archives

of Women's Mental Health*. https://doi.org/10.1007/s00737-016-0666-9

Van Schaik, D. J. F., Klijn, A. F. J., Van Hout, H. P. J., Van Marwijk, H. W. J., Beekman, A. T.

F., De Haan, M., & Van Dyck, R. (2004). Patients' preferences in the treatment of

depressive disorder in primary care. *General Hospital Psychiatry*.

https://doi.org/10.1016/j.genhosppsych.2003.12.001

Vieites, V., & Reeb-Sutherland, B. C. (2017). Individual differences in non-clinical maternal

depression impact infant affect and behavior during the still-face paradigm across the first

year. *Infant Behavior and Development*. https://doi.org/10.1016/j.infbeh.2017.02.005

Vliegen, N., Casalin, S., Luyten, P., Docx, R., Lenaerts, M., Tang, E., & Kempke, S. (2013). Hospitalization-based treatment for postpartum depressed mothers and their babies: Rationale, principles, and preliminary follow-up data. *Psychiatry (New York)*. https://doi.org/10.1521/psyc.2013.76.2.150

Weinberg, M. K., Beeghly, M., Olson, K. L., & Tronick, E. (2008). A Still-face Paradigm for Young Children: 2½ Year-olds' Reactions to Maternal Unavailability during the Still-face. *The Journal of Developmental Processes*.

Weissman, M. M., Gammon, G. D., John, K., Merikangas, K. R., Warner, V., Prusoff, B. A., & Sholomskas, D. (1987). Children of Depressed Parents: Increased Psychopathology and Early Onset of Major Depression. *Archives of General Psychiatry*. https://doi.org/10.1001/archpsyc.1987.01800220009002

Wenzel, A., Haugen, E. N., Jackson, L. C., & Brendle, J. R. (2005). Anxiety symptoms and disorders at eight weeks postpartum. *Journal of Anxiety Disorders*. https://doi.org/10.1016/j.janxdis.2004.04.001

Whitaker, R. C., Orzol, S. M., & Kahn, R. S. (2007). The co-occurrence of smoking and a major depressive episode among mothers 15 months after delivery. *Preventive Medicine*. https://doi.org/10.1016/j.ypmed.2007.07.005

Zadeh, M. A., Khajehei, M., Sharif, F., & Hadzic, M. (2012). High-risk pregnancy: Effects on

postpartum depression and anxiety. *British Journal of Midwifery*, *20*(2), 104–113. https://doi.org/10.12968/bjom.2012.20.2.104

Zheng, W., Cai, D. Bin, Sim, K., Ungvari, G. S., Peng, X. J., Ning, Y. P., Wang, G., & Xiang, Y. T. (2019). Brexanolone for postpartum depression: A meta-analysis of randomized controlled studies. In *Psychiatry Research*. https://doi.org/10.1016/j.psychres.2019.07.006